

CCNA 200-125

Routing & Switching

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NOA
NETWORK ONLINE ACADEMY

<u>INDEX</u>	<u>PAGE NO</u>
Basic networking Concepts /Network Devices	5
About Cisco & CCNA (exam & career paths) ..	14
TCP/IP ADDRESSING.....	18
Private & Public IP	39
Understanding LAN Connectivity	43
Introduction to Cisco Routers.....	50
Basic commands/ Modes of Cisco routers	62
Lab: Basic Configurations and Verifications	75
Understanding WAN connections.....	81
Rules to assign the ip address on cisco routers ..	88
Lab: basic IP configuration	95
Lab: Basic configuration using three routers	98
Troubleshooting Connectivity	104
WAN protocols (PPP/HDLC).....	105
PPP Authentication (PAP/CHAP)	107
LAB: PPP Authentication using CHAP	109
LAB: PPP Authentication using PAP	112
Subnetting	114
FLSM Examples	116
Understanding /Value	131
VLSM examples	133
Subnetting Questions	138
Routing	139
Static Routing	140
Lab: Static Routing	147
Lab: Static Routing (3routers)	150
Default routing:	159
LAB: DEFAULT ROUTING	162
Dynamic routing.....	165
Classfull /Classless	167
RIP v1/v2	168
Lab: Routing using RIPv2	172
Administrative Distance	181
Autonomous system number	182
EIGRP	185
Lab: EIGRP	191
OSPF	200

OSPF Areas	204
LAB: Configuring OSPF single Area	210
LAB: Configuring OSPF Multiple Area	214
Basic switching Concepts	222
Cisco Design hierarchy	232
Initial configuration of a switch	234
VIRTUAL LAN	242
LAB –Verify VLAN	248
Trunking	253
Lab: Trunking	259
Dynamic Trunking protocol	266
Inter-VLAN Routing	270
LAB: Inter-Vlan Routing Using Physical Gateway	274
Inter VLAN routing using subinterfaces	277
Inter VLAN routing using SVI (Multilayer switches)	282
Native VLAN	287
Extended VLAN	292
Voice VLAN	294
Native VLAN	287
VLAN Trunking Protocol (VTP)	297
LAB: Verifying VTP	303
Spanning-tree protocol	309
Lab: verifying spanning-tree	320
Ether-channel (Port-channel)	326
LAB : Configuring Etherchannel	331
Spanning-tree Portfast /BPDU Guard	335
Rapid STP	341
Access control list.....	349
LAB : Standard ACL	367
Lab : Extended ACL	371
Named ACL (standard/Extended)	385
Network address translation.....	394
LAB: Static NAT	400
LAB: Dynamic NAT	404
LAB: Port Address Translation	407
LAB: PATusing exit interface	413
IPV6	415
LAB: Basic configuration of Ipv6	427

Static and Default IPV6 routing	429
RIPng	431
OSPFv3	433
EIGRP FOR IPV6	435
DHCP on Cisco Routers	438
Logging on Cisco routers.....	445
Network Time Protocol	448
Switchport Analyser (SPAN)	455
First Hop Redundancy protocols (HSRP).....	457
Port-Security	468
DHCP Snooping overview	480
WAN Technologies	484
Leased lines	489
Metroethernet	492
Introduction to MPLS technology	494
Virtual private network (GRE,DMVPN, IPsec)	495
Multilink Point to point Protocol	501
PPPoE Overview	504
Password reverting on cisco routers	505
Lab: backup and restore IOS and configs	509
Restore IOS in Rommon Mode.....	516
Quality of service – Overview	519
OSI Reference model & TCP/IP.....	528
Troubleshooting Connectivity	542
Using CDP (lab).....	546
Troubleshooting VLAN / Trunking	556
Troubleshooting Routing (static /Default/Dynamic)	558
<u>CCNA Routing & Switching Workbook: Mock lab</u>	
CCNA Mock lab (Subnetting /IP configuration)	562
CCNA Mock lab (PPP Authentication).....	569
CCNA Mock lab (EIGRP /OSPF)	571
VLAN and Trunks	586
Inter-vlan routing	594
Spanning-tree protocol	598
Access Control List	601
Network Address Translation	604

Cisco Certified Network Associate

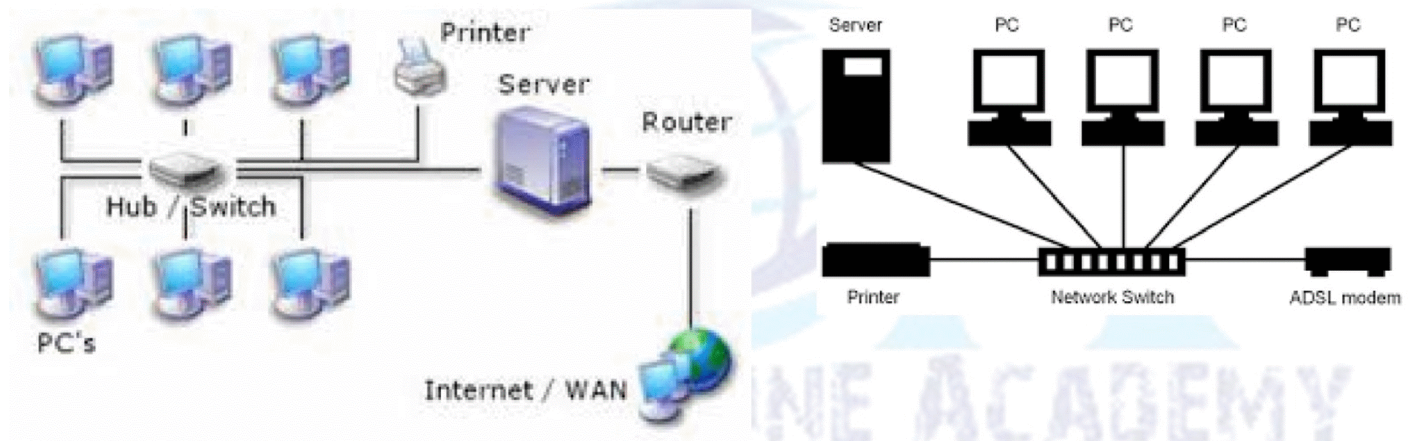
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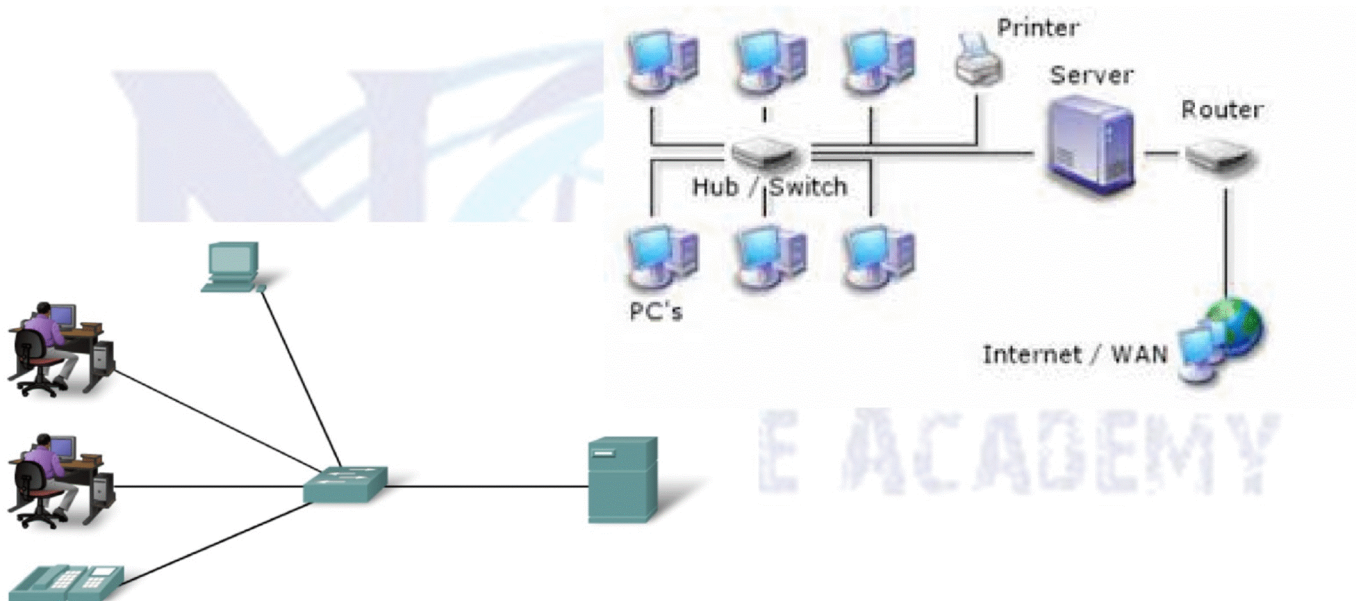
Network

Group of two or more computers connected to share information and resources.



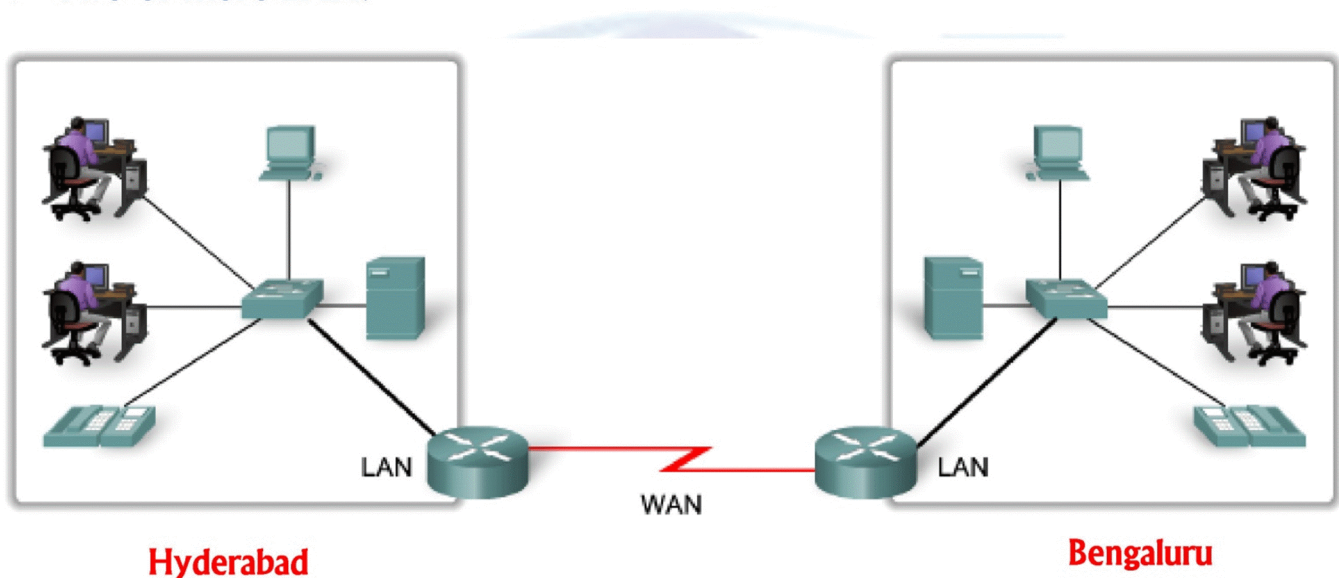
Local area networks (LAN)

Set of devices connected with the same location (office/building)



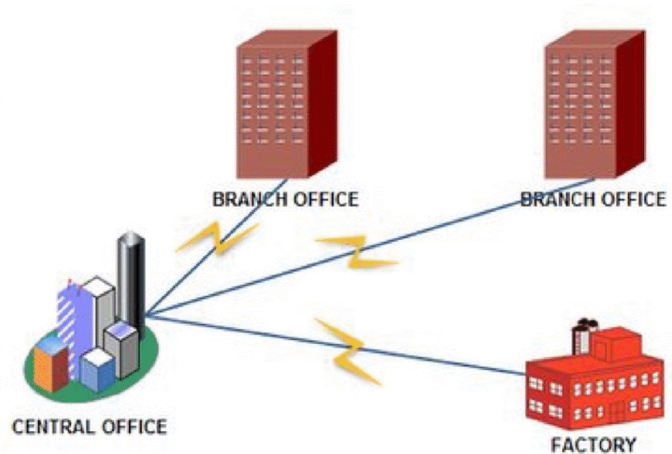
Wide Area Network (WAN)

- ▶ Set of devices connected in two or more different locations.
- ▶ Two or more LAN.



Metro-politan Area Network (MAN)

Set of devices connected in city limits



Personal area network (PAN)

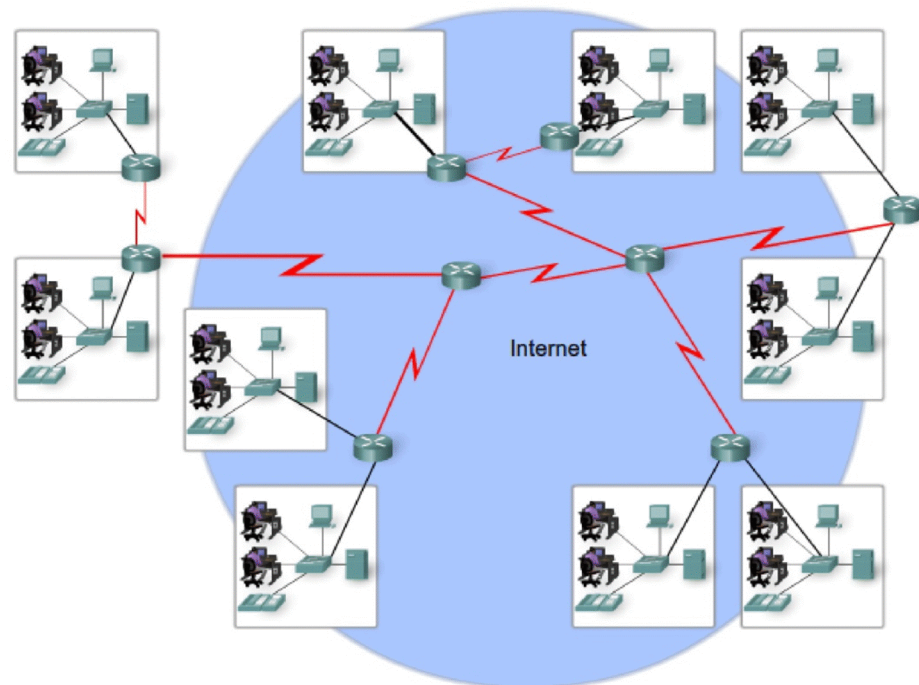
two or more computer systems with in 4 to 6 meters.



LANs, WANs, and Internets

The Internet

LANs and WANs may be connected into internetworks.



Providing Resources in a Network

Networks of Many Sizes



Small Home Networks



Small Office/Home Office Networks



Medium to Large Networks



World Wide Networks

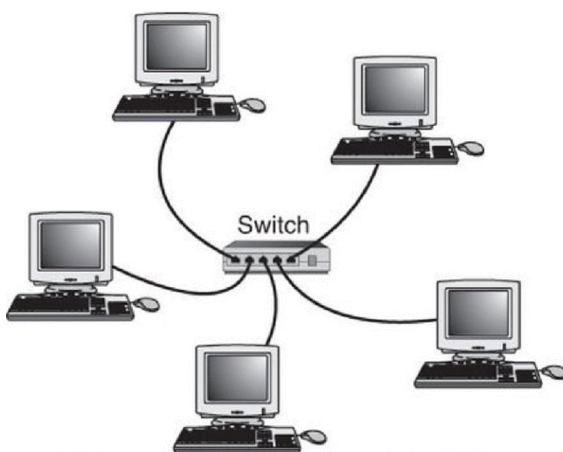
Network devices

Router, switch , firewall, voice devices, wireless Access-point

Cisco Switch



Provides centralized location to connect devices with in the LAN.



Switch



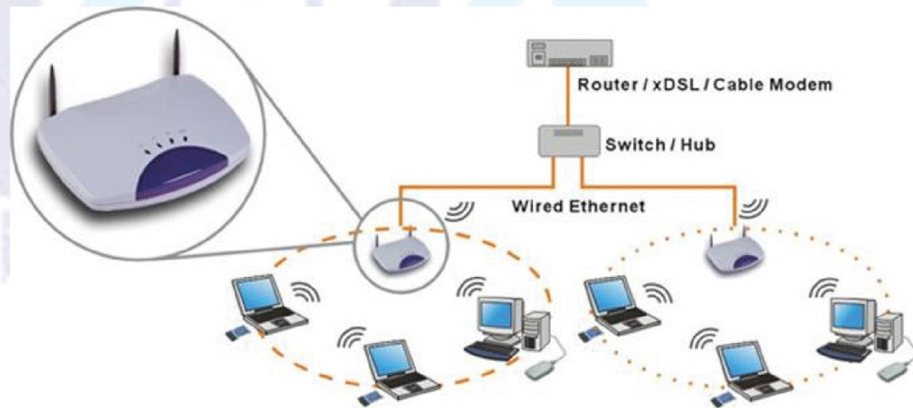
Rj45 Cable

Wireless Access point

- ▶ Provides centralized location to connect devices with in the LAN.
- ▶ Without wire (using RF signals)

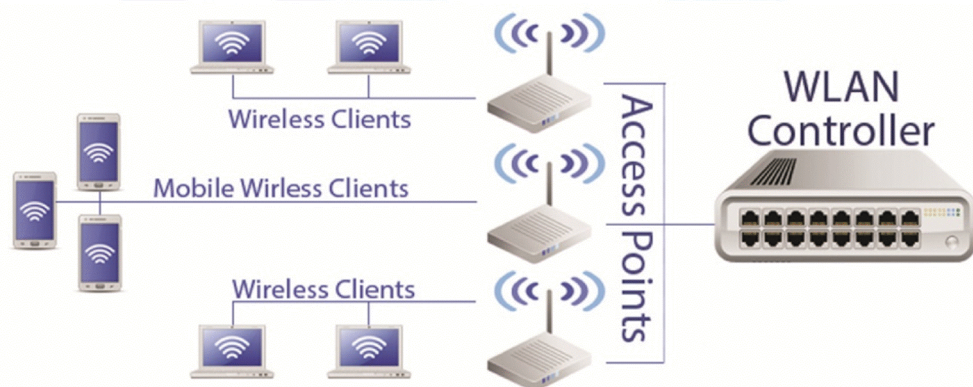


Wi Fi



Wireless LAN Controllers (WLC)

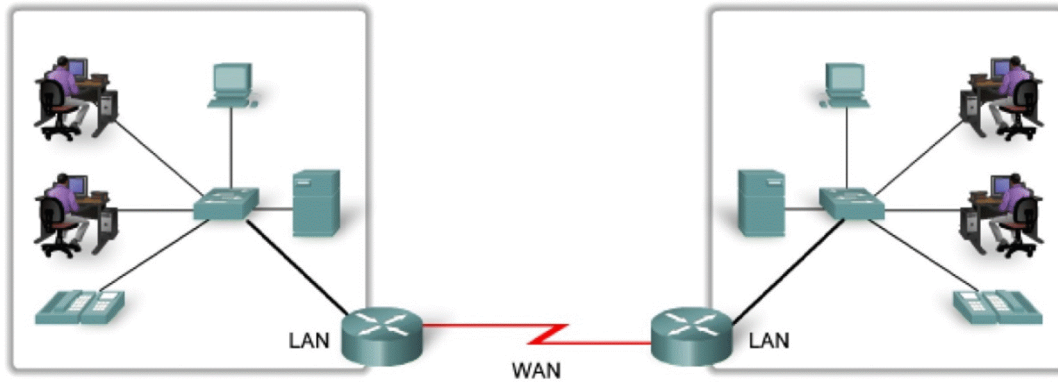
- ▶ Provides centralized management of all access points in the networks.
- ▶ make it easier to manage large wireless scale deployments.
 - Example : Airports, Shopping Malls



- ▶ More in depth on this in cisco you have CCNA CCNP CCIE Wireless track.

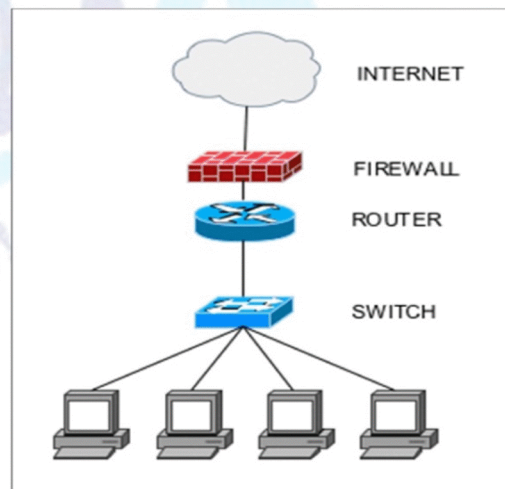
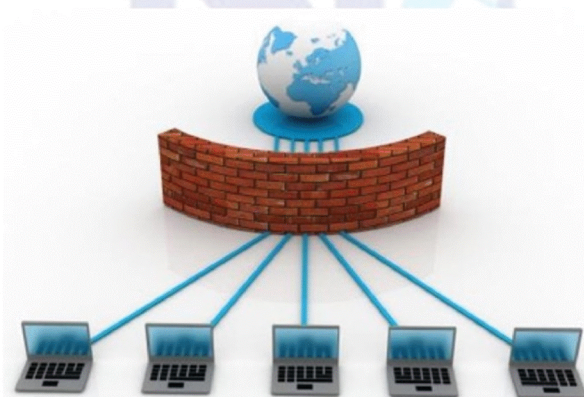
Cisco Routers

Device connecting two or more LAN



Cisco Firewall

- protects a network from unauthorized access
- controls incoming and outgoing network traffic based on a set of rules.



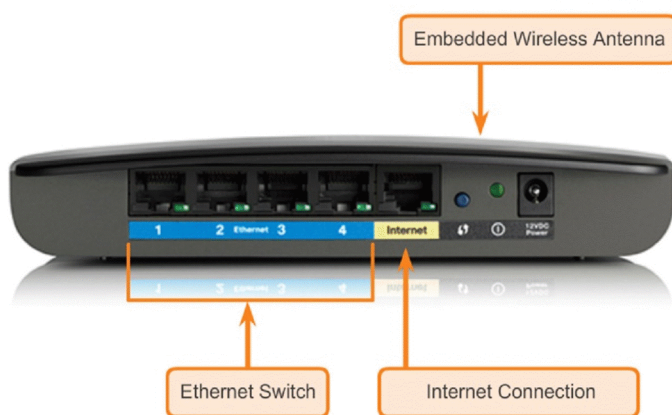
VoIP Phones/ Voice Devices

A VoIP phone uses Voice over IP for placing and transmitting telephone calls over an IP network, such as the Internet, instead of the traditional public switched telephone network (PSTN).

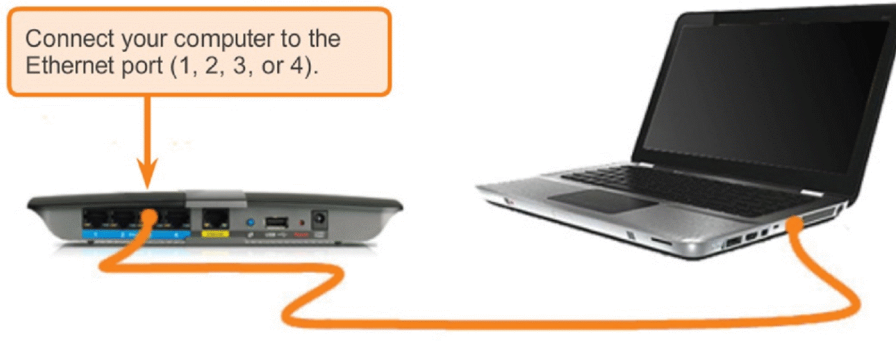


Home Internet devices

- ▶ Inbuilt Switch , Router, wireless AP
- ▶ Applicable for small home/office networks



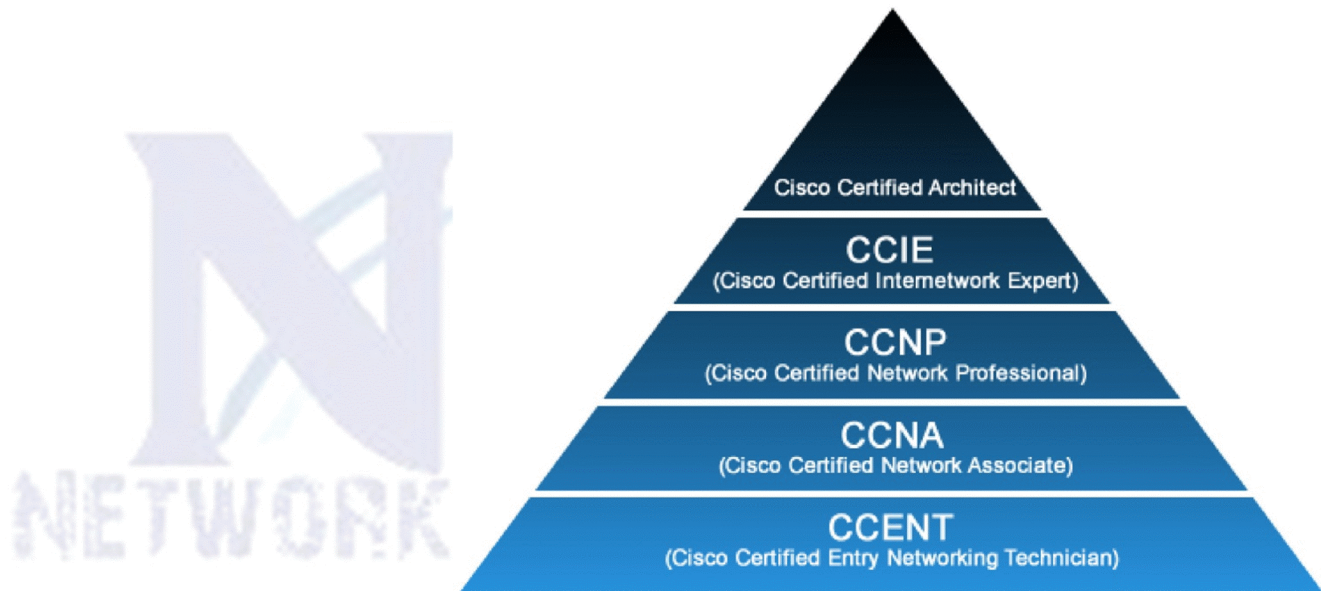
Connecting to the Wired LAN



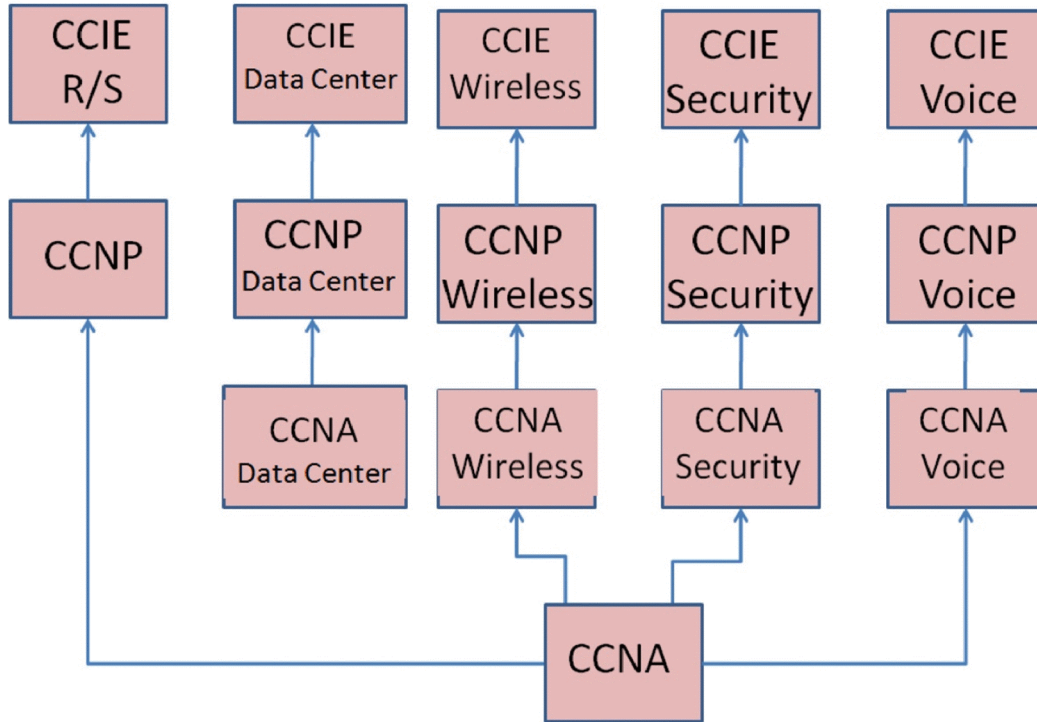
About Cisco

- ▶ Leading manufacturer of Networking Devices.
- ▶ Switches, Routers , Firewalls, Voice Devices, Datacenter , Wireless

Cisco Certification Tracks



Certification Tracks	Entry	Associate	Professional	Expert	Architect
Cloud		CCNA Cloud	CCNP Cloud		
Collaboration		CCNA Collaboration	CCNP Collaboration	CCIE Collaboration	
Data Center		CCNA Data Center	CCNP Data Center	CCIE Data Center	
Design	CCENT	CCDA	CCDP	CCDE	CCAr
Industrial		CCNA Industrial			
Routing and Switching	CCENT	CCNA Routing and Switching	CCNP Routing and Switching	CCIE Routing and Switching	
Security	CCENT	CCNA Security	CCNP Security	CCIE Security	
Service Provider		CCNA Service Provider	CCNP Service Provider	CCIE Service Provider	
Video		CCNA Video			
Voice	CCENT	CCNA Voice	CCNP Voice		
Wireless	CCENT	CCNA Wireless	CCNP Wireless	CCIE Wireless	



CCNA Certification Exam

- ▶ computer based
- ▶ run and administered by pearson VUE www.vue.com
- ▶ Cost 295 \$
- ▶ 90 minutes
- ▶ 50 – 55 Questions
- ▶ Cisco CCNA Exam Question Types
 - Multiple choice (MC)
 - Testlet (4 -5 questions on the same scenario diagram)
 - Drag-and-drop (DND)
 - Simulated lab (SIM)
 - Simlets (same as testlet need to use show commands to verify)
- ▶ Passing Score : 825/1000

Contents for new CCNA 200-125

- Network Fundamentals
- IP addressing (IPv4 / IPv6)
- LAN Switching Technologies
- IP Routing Technologies
- Infrastructure Services
- Infrastructure Security
- Infrastructure Management
- WAN Technologies
- Troubleshooting

For Detailed Contents

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Also you refer index pages in workbook provided.

What you get at NOA

- World class training in Hyderabad.
- Detailed lab workbooks for practice (500+ pages)
 - Includes slides & labs documented
 - Also includes mock lab (real-world scenario labs) .
 - Interview Questions in each section. (test your skills)
- Self paced Video on demand series.
- Simulation Tools for practice at home/lab.

- Duration – 30 days (90 min-per day) Monday - Saturday
- Lab timings- 7 am to 8 pm.
- Every month free seminar on (real time tools + interview preparation) by sikandar shaik CCIEx2 (RS/SP)

Test your Skills:

- Define router, switch and firewall?
- What is the difference between router and switch?
- What is the job of a firewall in our network?
- List the devices to be used in what is the range of Private IP address?
- What is VOIP?
- What is the purpose of Access point & WLC in the network?
- Explain the jobs done by router used in our homes internet?
- What are the certification tracks cisco offers?
- What are the types of questions covered in your CCNA online certification exam?



TCP/IP addressing

Protocol

set of rules to follow to have proper communication.

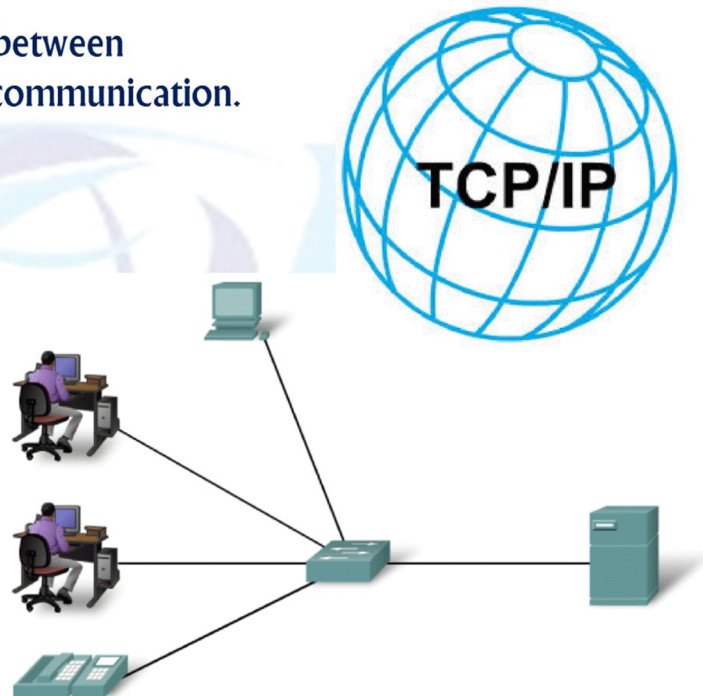
Network protocols

- TCP/IP (Department of Defense)
- IPx/SPx (Novell)
- Appletalk (Apple)
- Netbios (microsoft)
- OSI (ISO)



What is TCP/IP?

- ▶ TCP/IP is a standard protocol used between computers and network devices for communication.
- ▶ Internet work based on TCP/IP

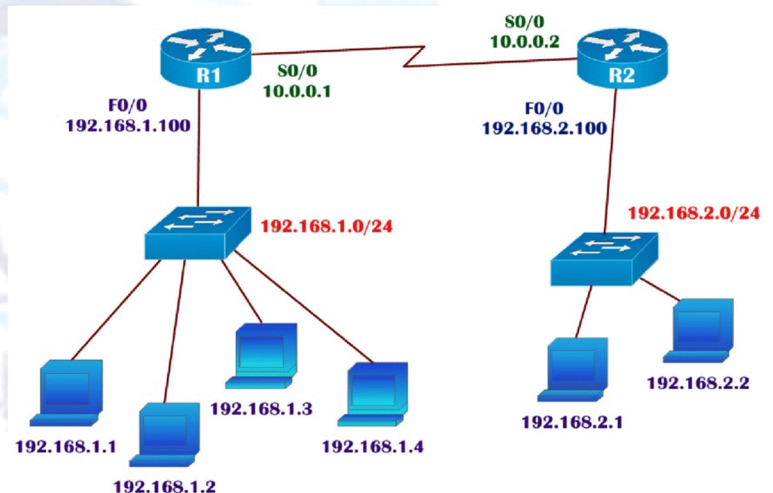
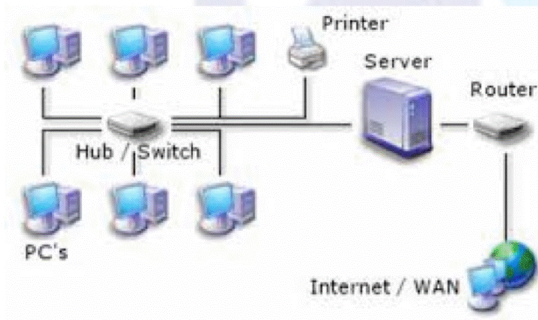


TCP/IP addressing

- ▶ IP Address is Logical Address given to each and every device in the network.
- ▶ IP address used to identify specific device in the network.

Two Versions of IP:

- IP version 4 (32 bit)
- IP version 6 (128 bit)



IPV4 address

32 bits

11000000

10100000

00000111

00000001

8 bits

8 bits

8 bits

8 bits

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1
1	1	0	0	0	0	0	0

192

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1
1	0	1	0	0	0	0	0

160

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1
0	0	0	0	0	1	1	1

7

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1
0	0	0	0	0	0	0	1

1

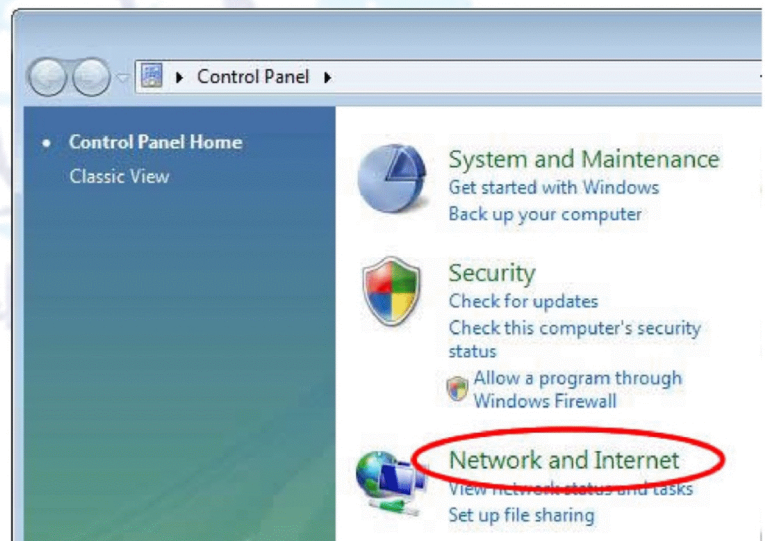
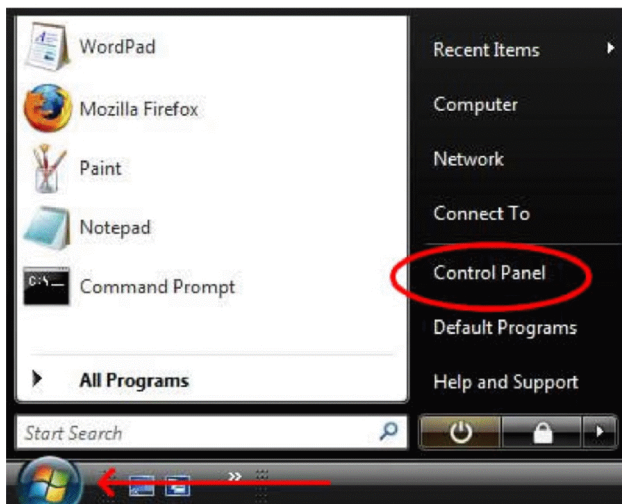
Convert Decimal to Binary

192.168.10.10

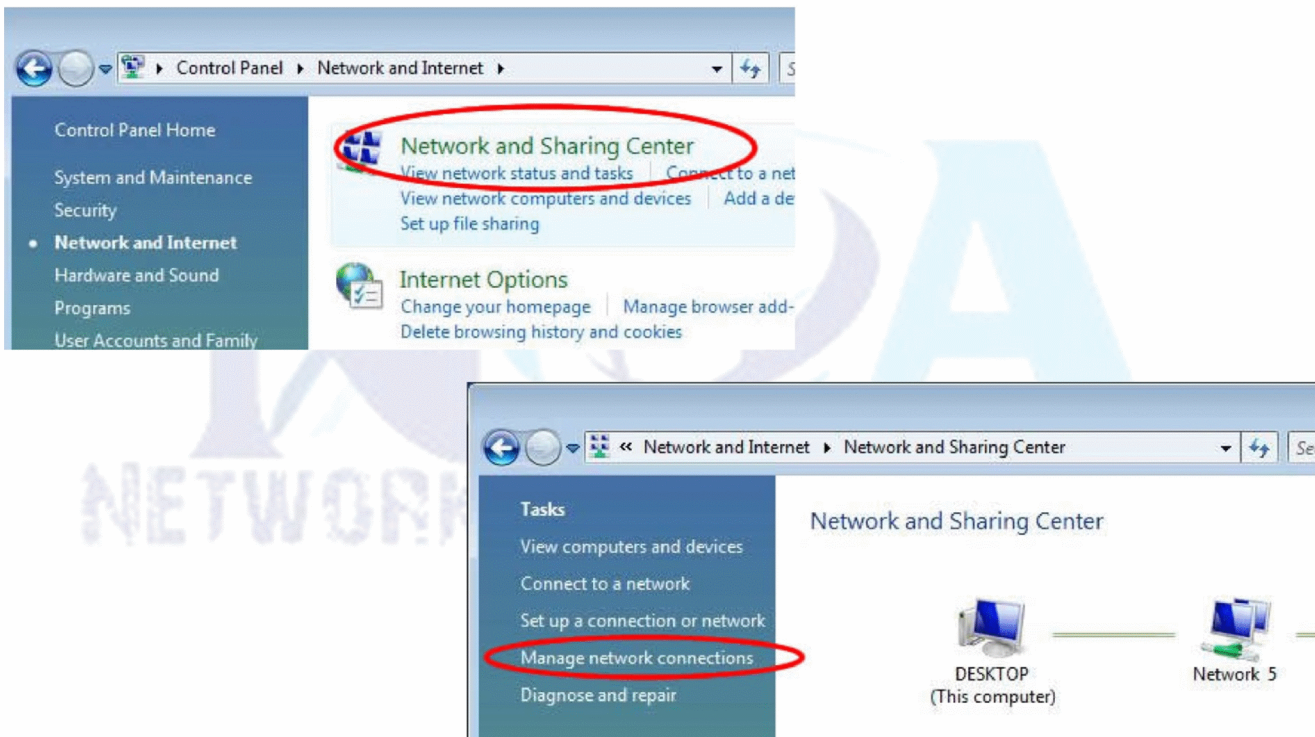
192 → 11000000
 168 → 10101000
 10 → 00001010
 10 → 00001010

NETWORK ONLINE ACADEMY

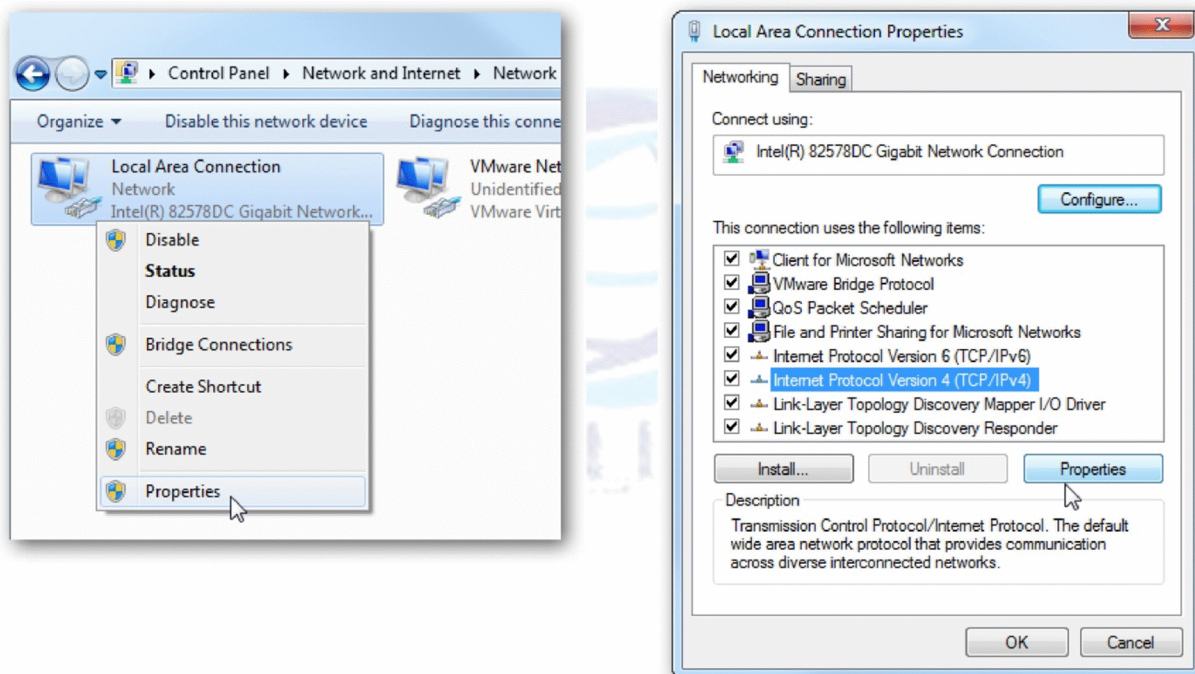
Assigning IPv4 address to a Host



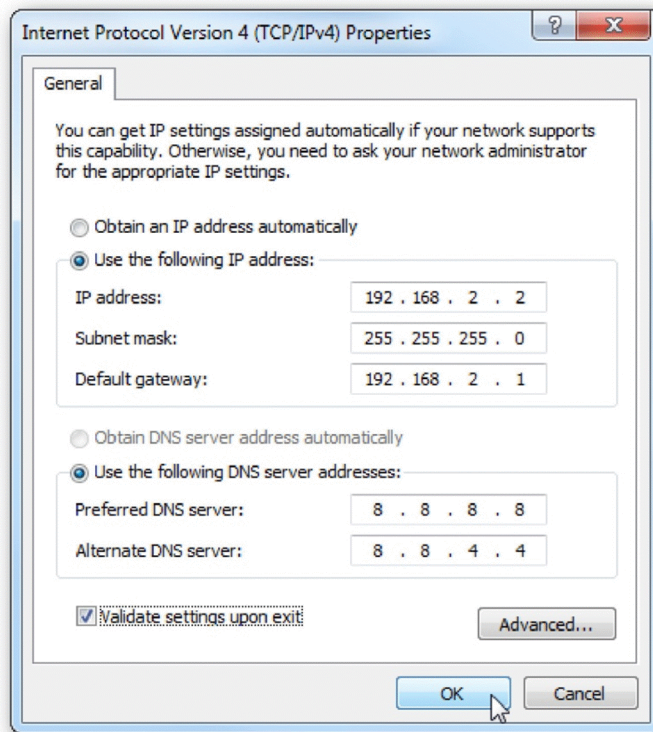
Assigning IPv4 address to a Host



Assigning IPv4 Address to a Host



Assigning IPv4 Address to a Host



Range of IPv4 address

Taking Example for First Octet :
Total 8 bits, Value will be 0's and 1's
i.e. $2^8 = 256$ combination

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
0	0	0	0	0	0	0	0	= 0
0	0	0	0	0	0	0	1	= 1
0	0	0	0	0	0	1	0	= 2
0	0	0	0	0	0	1	1	= 3
0	0	0	0	0	1	0	0	= 4

Total IP Address Range
0 . 0 . 0 . 0
to
255.255.255.255

1 1 1 1 1 1 1 1 = 255

IP Address Classification

IP Addresses are divided into 5 Classes

CLASS A 0-127

CLASS B 128 - 191

CLASS C 192-223

Used in LAN & WAN

CLASS D 224-239

Reserved for Multicasting

CLASS E 240-255

Reserved for Research & Development

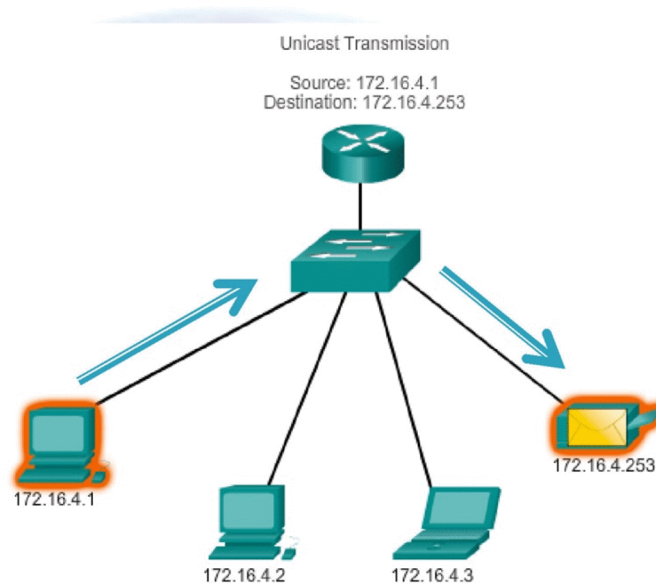
Types of communication

In an IPv4 network, the hosts can communicate one of three different ways:

1. Unicast
2. Broadcast
3. Multicast

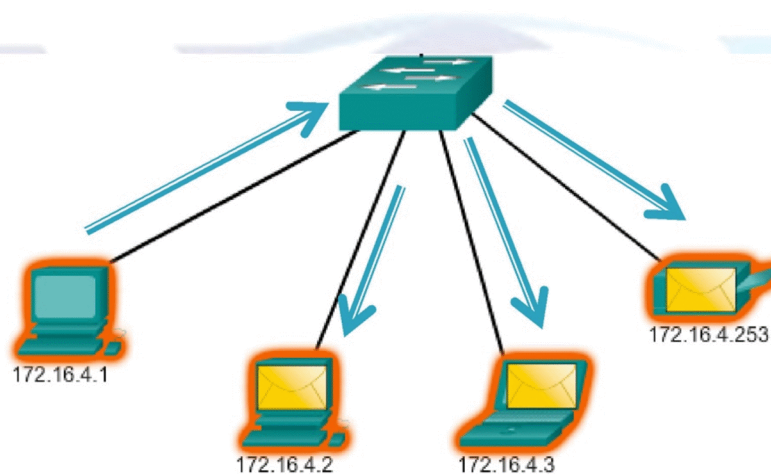
Unicast Transmission

the process of sending a packet from one host to an individual host.



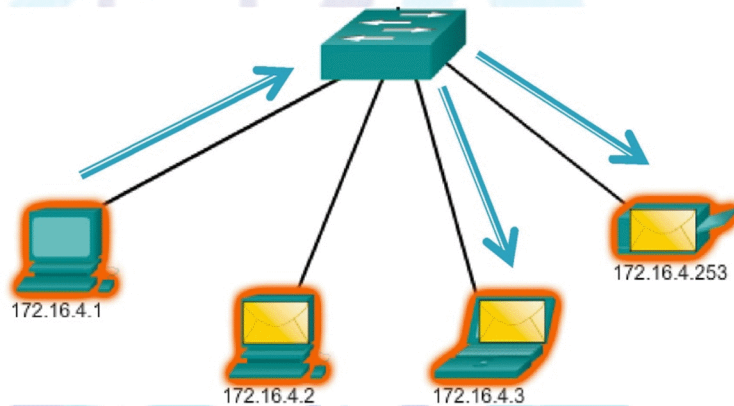
Broadcast Transmission

The process of sending a packet from one host to all hosts in the network



Multicast Transmission

- The process of sending a packet from one host to a selected group of hosts, possibly in different networks
- CLASS D 224-239 Reserved for Multicasting



**Live TV and Radio Broadcast
to the Desktop**

Corporate Broadcasts

**Multicast File Transfer
Data and File Replication**

Distance Learning



Training

Videoconferencing

Video-on-Demand

Whiteboard/Collaboration

Real-Time Data Delivery—Financial

Network & Host portions

IP address is divided into Network & Host Portion

CLASS A N.H.H.H

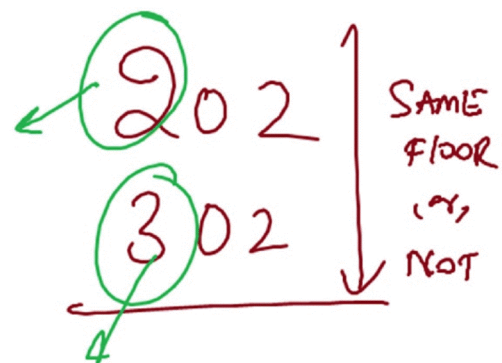
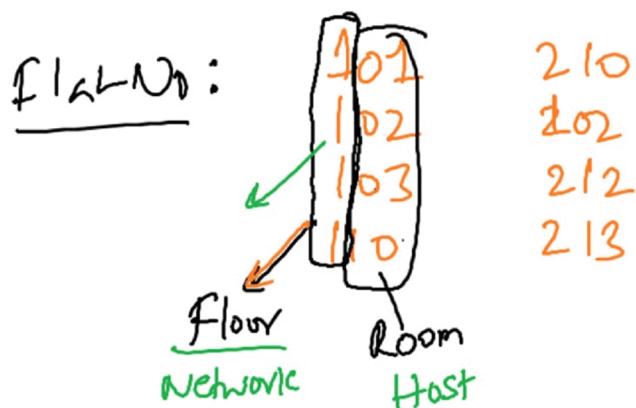
CLASS B N.N.H.H

CLASS C N.N.N.H

Host: a specific device in the network

Network: set of devices

Host → one single Device
Network → Set of Devices



A → N · H · H · H
B → N · N · H · H
C → N · N · N · H

	N	N	N	
R	192	168	10	1
D	192	168	12	1

0-127 | A
128-191 | B
192-223 | C

different
~~Same Networks~~, (4, Not
N-Same

	N	N	N	
C	210	10	10	10
	210	12	12	12

different

	N	N	
B	150-12	10	10
	150-12	15	15

Same

N · H · H · H
A ← 100 · 10 · 10 · 10
100 · 15 · 15 · 15
Same

0x 1x 2

0-127 | A
128-191 | B
192-223 | C

Class C-Range N.N.N.H

192.168.1.X

192.168.1.0

192.168.1.1

192.168.1.2

192.168.1.3

....

....

....

....

192.168.1.253

192.168.1.254

192.168.1.255

First three portions has to be same in order to be in the same network.

X = 0-255

N.N.N.H

Class B - Range N.N.H.H

172.16.X.X

First two portions has to be same in order to be in the same network

X = 0-255

172.16.0.0

172.16.1.0

172.16.2.0

172.16.255.0

172.16.0.1

172.16.1.1

172.16.2.1

172.16.255.1

172.16.0.2

172.16.1.2

172.16.2.2

172.16.255.2

172.16.0.3

172.16.1.3

172.16.2.3

172.16.255.3

....

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172.16.0.254

172.16.1.254

172.16.2.254

172.16.255.254

172.16.0.255

172.16.1.255

172.16.2.255

172.16.255.255

Class A-Range

N.H.H.H

10.X.X.X



First one portions has to be same in order to be in the same network

X = 0-255

10.0.0.0	10.0.1.0	10.0.2.0	10.0.255.0
10.0.0.1	10.0.1.1	10.0.2.1	10.0.255.1
10.0.0.2	10.0.1.2	10.0.2.2	10.0.255.2
10.0.0.3	10.0.1.3	10.0.2.3	10.0.255.3
....			
....			
....			
....			
10.0.0.254	10.0.1.254	10.0.2.254	10.0.255.254
10.0.0.255	10.0.1.255	10.0.2.255	10.0.255.255

Class A-Range

N.H.H.H

10.X.X.X



10.1.0.0	10.1.1.0	10.1.2.0	10.1.255.0
10.1.0.1	10.1.1.1	10.1.2.1	10.1.255.1
10.1.0.2	10.1.1.2	10.1.2.2	10.1.255.2
10.1.0.3	10.1.1.3	10.1.2.3	10.1.255.3
....			
....			
....			
....			
10.1.0.254	10.1.1.254	10.1.2.254	10.1.255.254
10.1.0.255	10.1.1.255	10.1.2.255	10.1.255.255

Class A-Range

N.H.H.H

10.x.x.x

10.255.0.0	10.255.1.0	10.255.2.0	10.255.255.0
10.255.0.1	10.255.1.1	10.255.2.1	10.255.255.1
10.255.0.2	10.255.1.2	10.255.2.2	10.255.255.2
10.255.0.3	10.255.1.3	10.255.2.3	10.255.255.3
....			
....			
....			
....			
10.255.0.254	10.255.1.254	10.255.2.254	10.255.255.254
10.255.0.255	10.255.1.255	10.255.2.255	10.255.255.255

- | | | |
|-------------------|---------|-------------|
| ▶ Class C - Range | N.N.N.H | 192.168.1.x |
| ▶ Class B - Range | N.N.H.H | 172.16.x.x |
| ▶ Class A - Range | N.H.H.H | 10.x.x.x |

Number of hosts address in each class

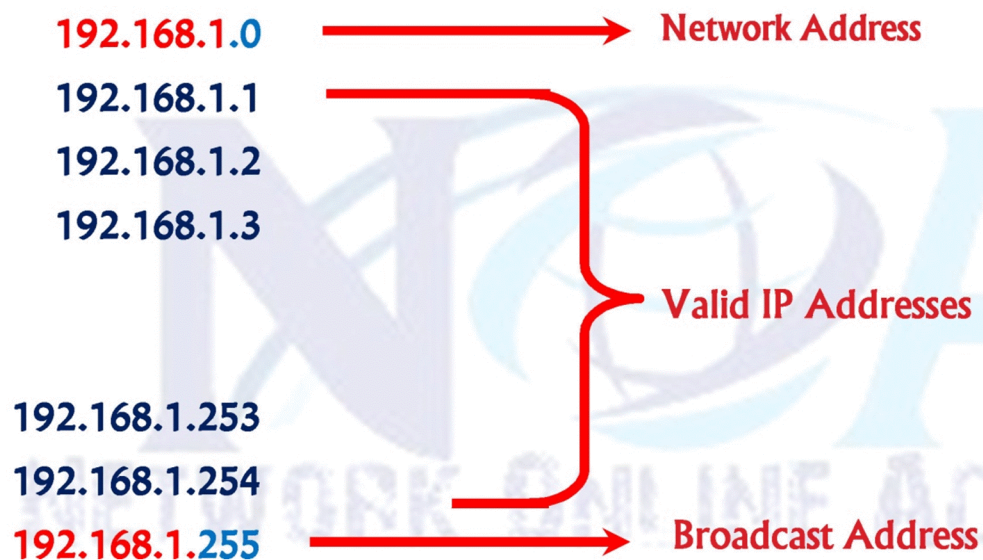
- | | | |
|-------------------|---------------|---------------------|
| ▶ Class C - Range | host bits= 8 | $2^8 = 256$ |
| ▶ Class B - Range | host bits= 16 | $2^{16} = 65536$ |
| ▶ Class A - Range | host bits= 24 | $2^{24} = 16777216$ |

Number of valid hosts address

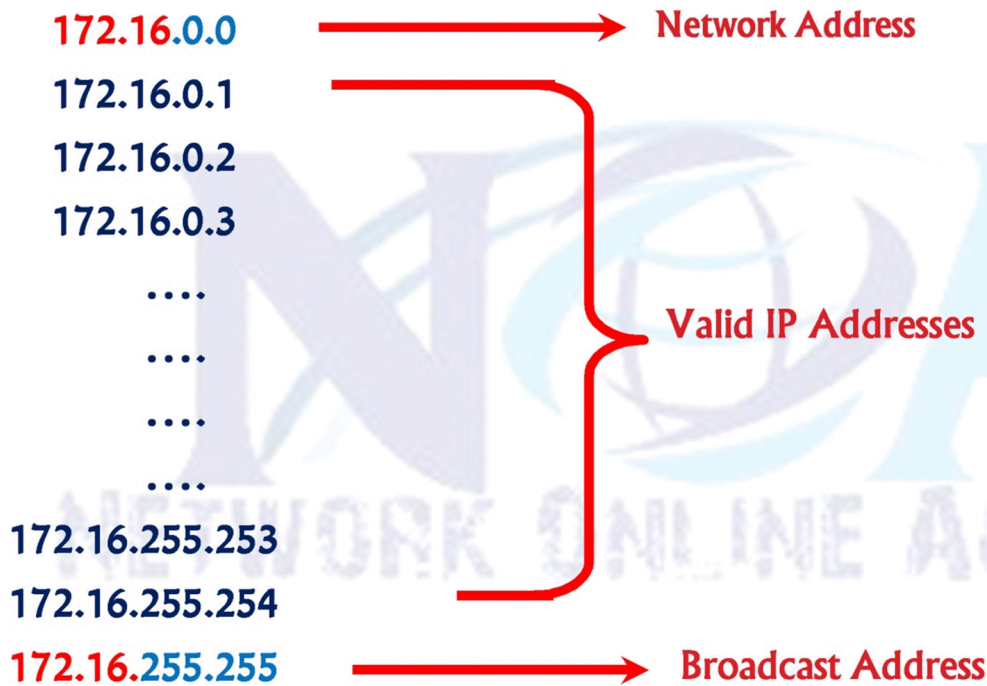
▶ Class C	N.N.N.H	host bits= 8	$2^8 = 256-2$
▶ Class B	N.N.H.H	host bits= 16	$2^{16} = 65536-2$
▶ Class A	N.H.H.H	host bits= 24	$2^{24} = 16777216-2$

First and last address in each range are reserved for Network ID and Broadcast ID.

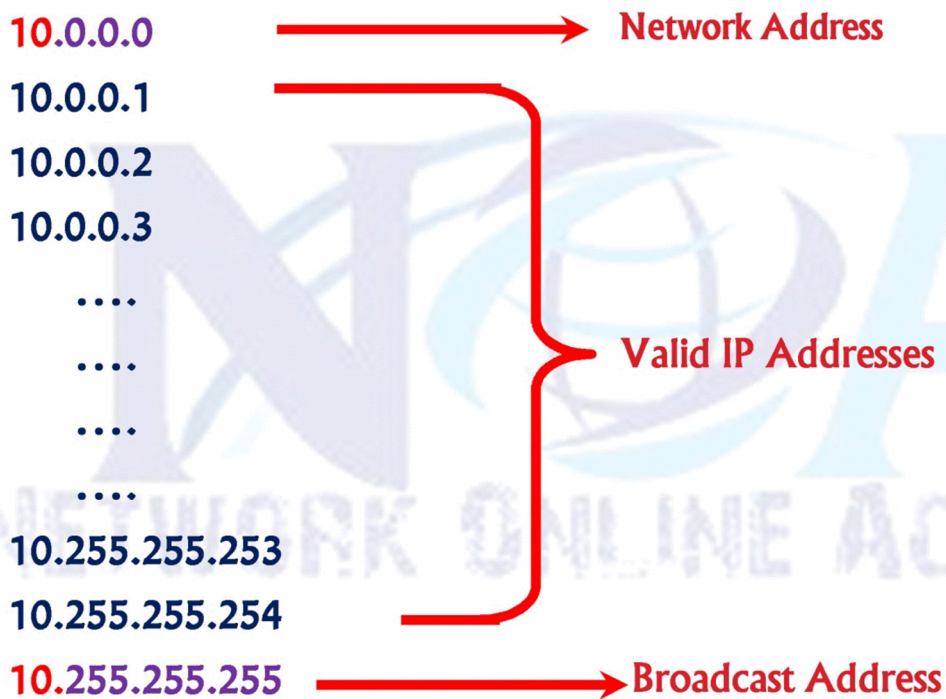
Class-C



Class -B



Example - Class A



Network & Broadcast Address

Network ID :

- First IP of the range
- All ZERO's in the host portion
- Reserved for Identifying complete network.

Class C	N.N.N.H	192.168.1.X	192.168.1.0
Class B	N.N.H.H	172.16.X.X	172.16.0.0
Class A	N.H.H.H	10.X.X.X	10.0.0.0

Broadcast Address

Broadcast address

- Last IP address of the range
- All ONE'S in the host portion
- Used to send broadcast to all with in the same network

Class C	N.N.N.H	192.168.1.X	192.168.1.255
Class B	N.N.H.H	172.16.X.X	172.16.255.255
Class A	N.H.H.H	10.X.X.X	10.255.255.255

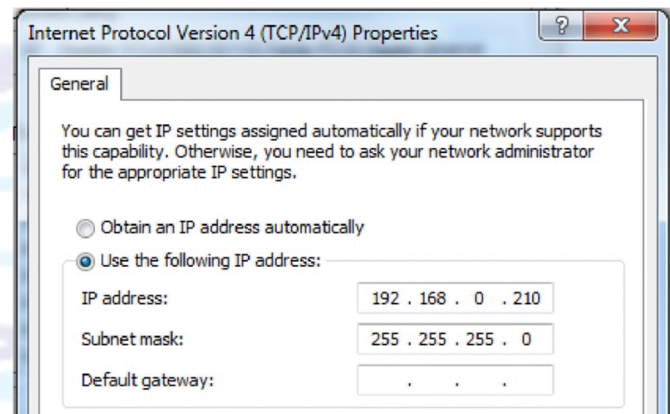
Valid IP

- Valid IP Addresses lie between the Network Address and the Broadcast Address.
- Only Valid IP Addresses are assigned to hosts/clients

Subnet-mask

Subnet Mask differentiates the Network and Host Portion.

- 1 represent **network**
- 0 represent **hosts**



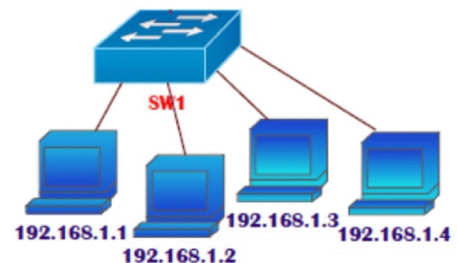
Class A	N.H.H.H	255.0.0.0
Class B	N.N.H.H	255.255.0.0
Class C	N.N.N.H	255.255.255.0

Reserved Address

- ▶ Class D 224.X.X.X - 239.X.X.X
- ▶ Class E 240.X.X.X -255.X.X.X
- ▶ Network ID & Broadcast ID
- ▶ 0.X.X.X not valid
- ▶ 127.X.X.X for loopback address (testing TCP/IP)

Ping Command

Used for Testing connectivity between two devices.



Ipconfig

```

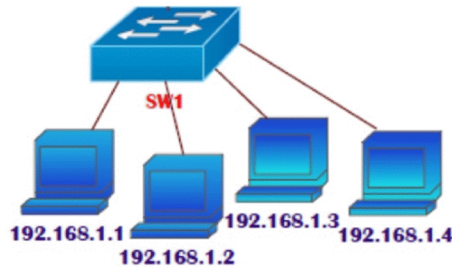
C:\Windows\system32\cmd.exe
Microsoft Windows [Version 6.1.7100]
Copyright (c) 2009 Microsoft Corporation. All rights reserved.

C:\Users\grooveDexter>ipconfig

Windows IP Configuration

Ethernet adapter Local Area Connection:

    Connection-specific DNS Suffix  . : hse.wa.comcast.net.
    Link-local IPv6 Address . . . . . : fe80::dcd8:42af:
    IPv4 Address. . . . . : 192.168.1.125
    Subnet Mask . . . . . : 255.255.255.0
    Default Gateway . . . . . : 192.168.1.1
  
```



Ping 192.168.1.1

```

C:\Windows\system32\cmd.exe - ping 192.168.1.1
Microsoft Windows [Version 6.1.7600]
Copyright (c) 2009 Microsoft Corporation. All rights reserved.

C:\Users\User>ping 192.168.1.1

Pinging 192.168.1.1 with 32 bytes of data:
Reply from 192.168.1.1: bytes=32 time=1ms TTL=255
Reply from 192.168.1.1: bytes=32 time=1ms TTL=255
Reply from 192.168.1.1: bytes=32 time=1ms TTL=255
Reply from 192.168.1.1: bytes=32 time=1ms TTL=255

Ping statistics for 192.168.1.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 1ms, Maximum = 1ms, Average = 1ms
  
```

Ping 192.168.1.1

```

K:\WINNT\system32\cmd.exe
C:\>
C:\>ping 192.168.0.1

Pinging 192.168.0.1 with 32 bytes of data:

Request timed out.
Request timed out.
Request timed out.
Request timed out.

Ping statistics for 192.168.0.1:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0ms
  
```

```

C:\Documents and Settings\Administrator>ping 9.83.0.1

Pinging 9.83.0.1 with 32 bytes of data:

Destination host unreachable.
Destination host unreachable.
Destination host unreachable.
Destination host unreachable.

Ping statistics for 9.83.0.1:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
  
```


Ipconfig /all

```
C:\Documents and Settings>ipconfig /all

Windows IP Configuration

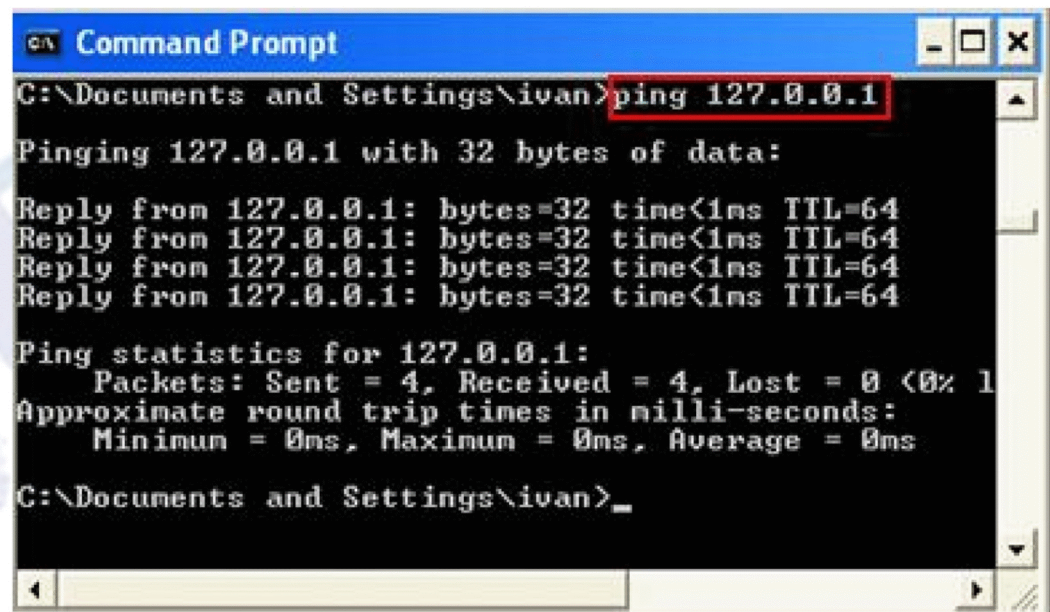
    Host Name . . . . . : xpbx
    Primary Dns Suffix . . . . . : 
    Node Type . . . . . : Unknown
    IP Routing Enabled. . . . . : No
    WINS Proxy Enabled. . . . . : No

Ethernet adapter Local Area Connection:

    Connection-specific DNS Suffix . : 
    Description . . . . . : VMware Accelerated AMD
    Physical Address. . . . . : 00-0C-29-3D-5E-41
    Dhcp Enabled. . . . . : No
    IP Address. . . . . : 192.168.1.17
    Subnet Mask . . . . . : 255.255.255.0
    Default Gateway . . . . . : 192.168.1.254
    DNS Servers . . . . . : 192.168.1.2
```

127.x.x.x - loopback address

Loopback address used for testing local TCP/IP protocols



```
Command Prompt

C:\Documents and Settings\ivan>ping 127.0.0.1

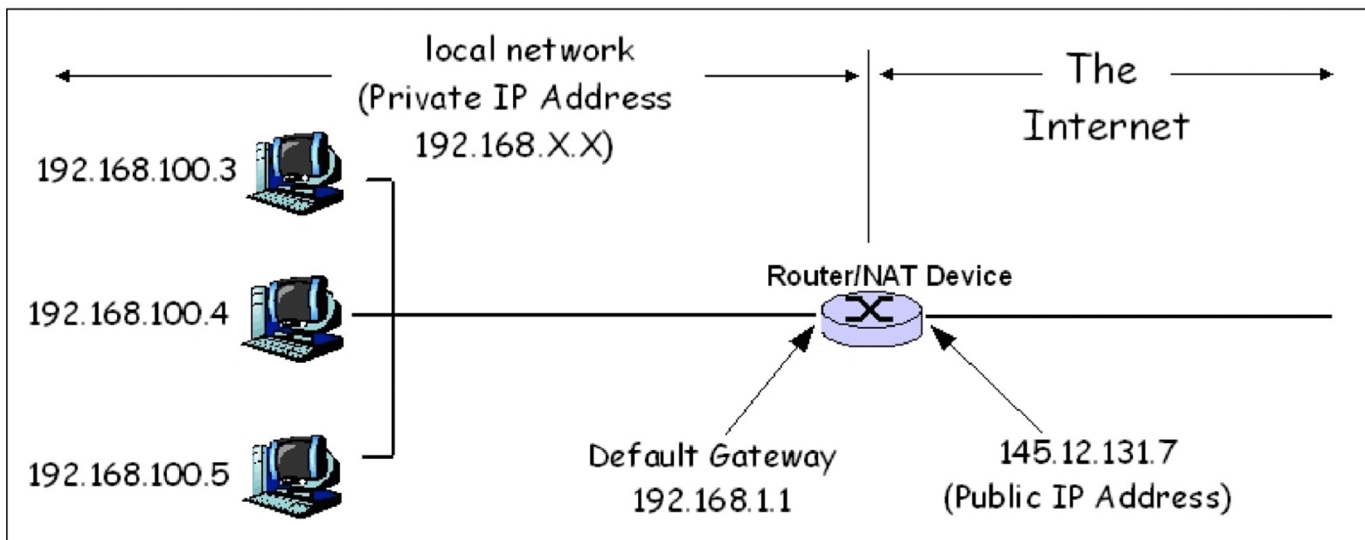
Pinging 127.0.0.1 with 32 bytes of data:

Reply from 127.0.0.1: bytes=32 time<1ms TTL=64
Reply from 127.0.0.1: bytes=32 time<1ms TTL=64
Reply from 127.0.0.1: bytes=32 time<1ms TTL=64
Reply from 127.0.0.1: bytes=32 time<1ms TTL=64

Ping statistics for 127.0.0.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss)
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Documents and Settings\ivan>
```

Private & Public IP



Public IP

Private IP

- | | |
|--|--|
| ▶ Used on public network(INTERNET) | ▶ Used with the LAN or within the organization |
| ▶ Recognized on internet | ▶ Not recognized on internet |
| ▶ Given by the service provider (from IANA) | ▶ Given by the administrator |
| ▶ Globally unique | ▶ Unique within the network or organization |
| ▶ Pay to service provider (or IANA) | ▶ Free |
| ▶ Registered | ▶ Unregistered IP |

Private IP Address

There are certain addresses in each class of IP address that are reserved for Private Networks. These addresses are called private addresses.

Class A	10.0.0.0	to	10.255.255.255	(10.x.x.x)
Class B	172.16.0.0	to	172.31.255.255	
Class C	192.168.0.0	to	192.168.255.255	(192.168.x.x)

Assignment of IP Addresses

Regional Internet Registries (RIRs)

The major registries are: (IANA.org)

<http://www.iana.org/assignments/ipv4-address-space/ipv4-address-space.xhtml>

Assignment of IP Addresses



Test your Skills:

Define protocol and list some protocols used in network?

What is TCP/IP?

Why do we need IP address?

Why there is a need for IPv6 addressing when already we have IPv4?

Write the Binary Conversion of given decimal values

- 155
- 245
- 220
- 66

Write the Decimal Conversion of given Binary values

- 11100011
- 00110011
- 11110000
- 10100011

List out the range of IP addressing from A to E?

Define unicast, Multicast, Broadcast?

Write the number of network & host portions in class A, B, C?

Write down the class which the given address belong

- 192.168.10.1
- 150.1.1.1
- 200.15.12.10
- 10.12.145.10
- 125.1.1.1

Identify the given address whether they are in the same network or different networks based on default network and host portions.

- 192.168.1.1
- 192.168.20.1

=====

- 150.25.25.100
- 150.25.22.10

=====

- 100.10.10.10
- 100.45.10.15

=====

- 110.12.15.10
- 110.14.12.100

=====

- 172.25.25.100
- 172.21.22.10

=====

Write down the range, network ID and Broadcast ID for network 172.16.0.0

Write down the range, network ID and Broadcast ID for network 192.168.0.0

Write down the range, network ID and Broadcast ID for network 100.0.0.0

Write the network ID and Broadcast ID for the following given IP address.

- 172.16.15.10
- 192.168.20.10
- 215.10.10.10
- 100.10.10.10
- 145.12.25.15

Check the following IP address given and identify whether the given IP is network ID or broadcast ID or Valid IP.

- 100.15.0.0
- 210.15.10.0
- 192.168.10.255
- 172.16.2.255
- 100.0.255.255
- 175.10.145.255
- 175.12.0.0

Define subnet mask and write the default subnet mask for each class?

List the Reserved address and explain where they are used?

What are the command in PC we use for verifying IP ADDRESS and connectivity?

Differentiate between private and Public IP?

Write the range of private IP in each class?

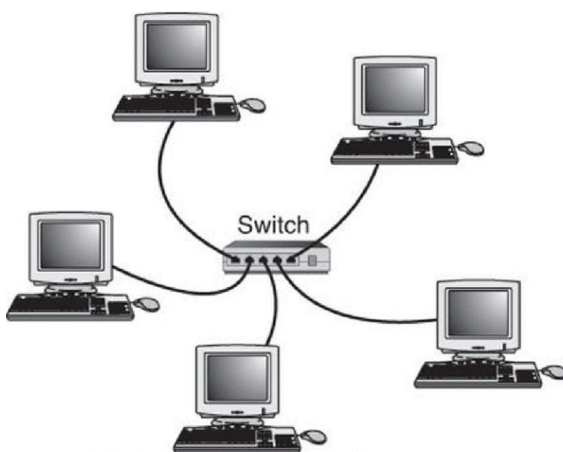
Which two of the following are private IP addresses?

- A. 12.0.0.1
- B. 168.172.19.39
- C. 172.20.14.36
- D. 172.33.194.30
- E. 192.168.24.43

Introduction to Switch & Router

Cisco Switch

Provides centralized location to connect devices with in the LAN.



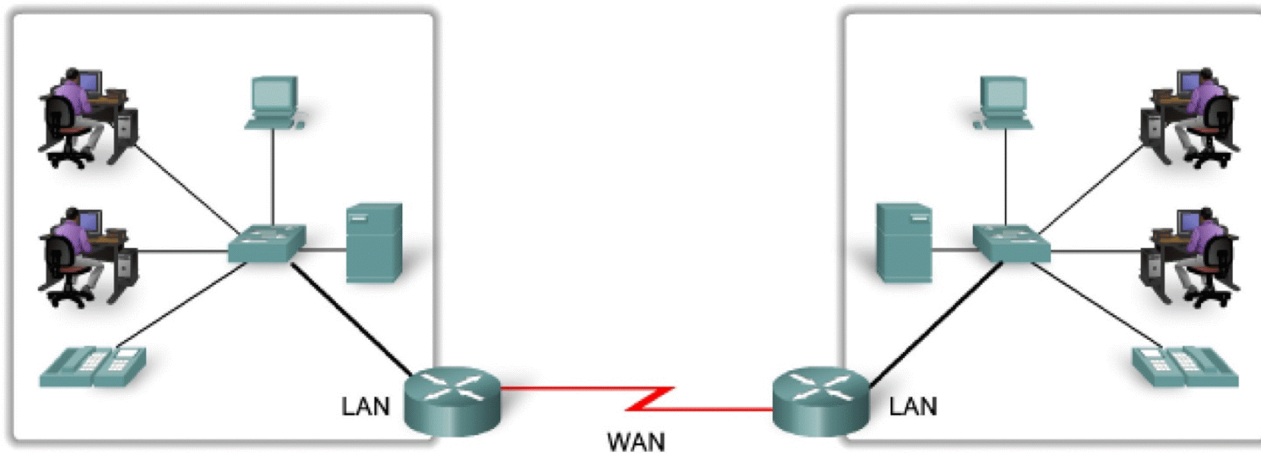
Switch



Rj45 Cable

Cisco Routers

Device connecting two or more LAN

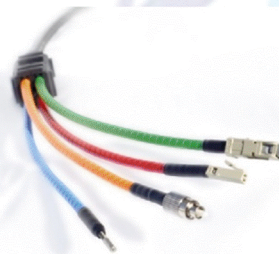
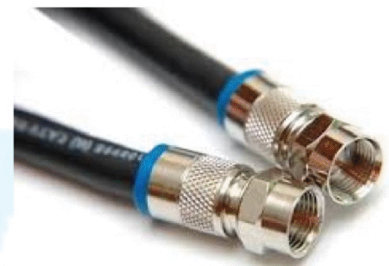


Hyderabad

Bengaluru

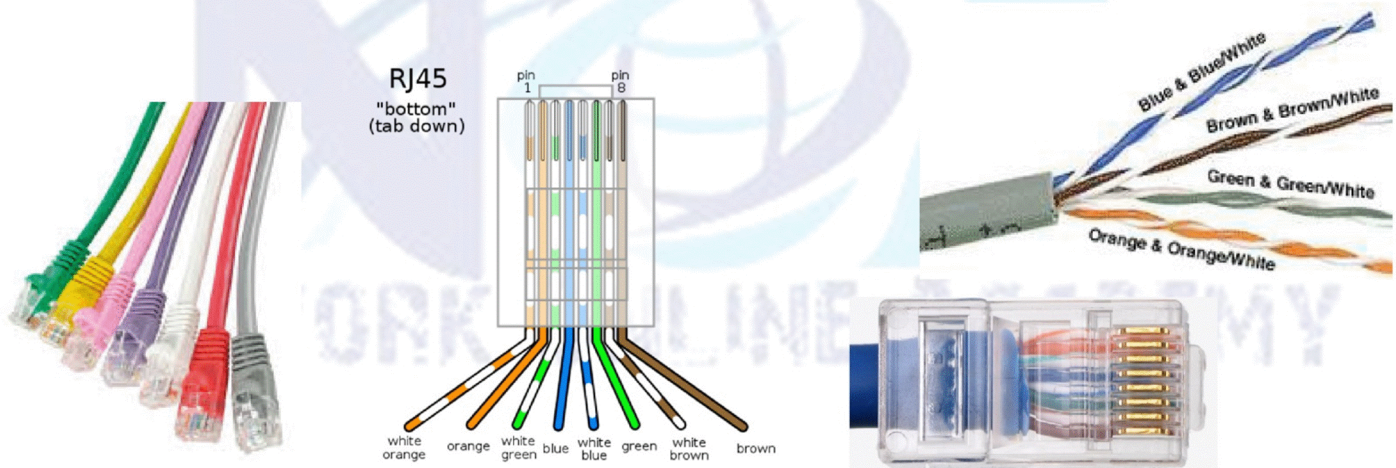
Media Types

1. Copper cables (UTP & Co-axial)
2. Fiber Optic cables
3. Wireless (RF signals)



UTP cable

- Used for connecting devices within the LAN
- Support distance of maximum 100 mts
- straight or cross cables based on alignment of wires inside RJ45 jack

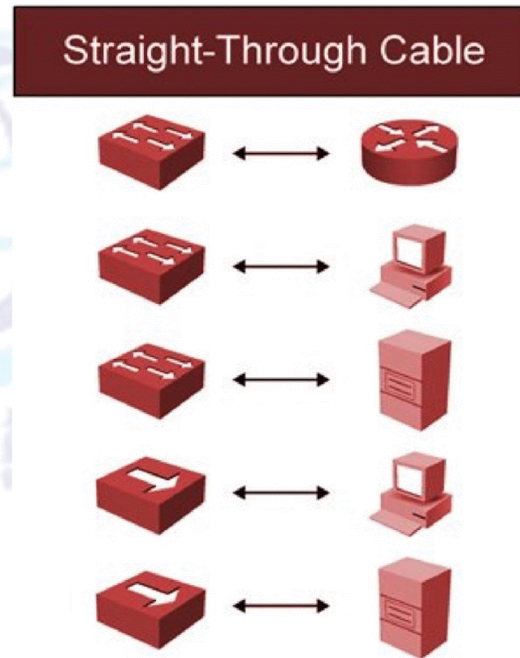


UTP straight cable color coding

White/orange	-	White/orange
Orange	-	Orange
White/green	-	White/green
Blue	-	Blue
White/blue	-	White/blue
Green	-	Green
White/brown	-	White/brown
Brown	-	brown

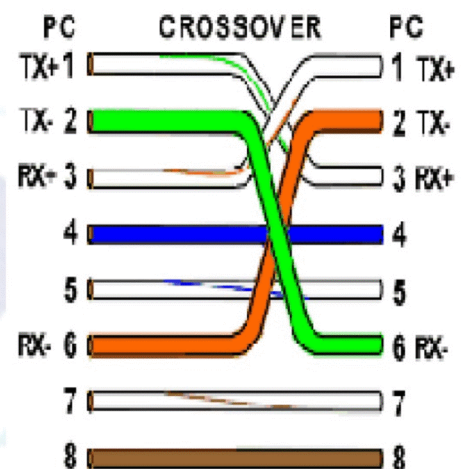
PC	STRAIGHT-THRU	HUB
TX+ 1	1	1 RX+
TX- 2	2	2 RX-
RX+ 3	3	3 TX+
4	4	4
5	5	5
RX- 6	6	6 TX-
7	7	7
8	8	8

UTP straight cable used to connect between **dis-similar devices**

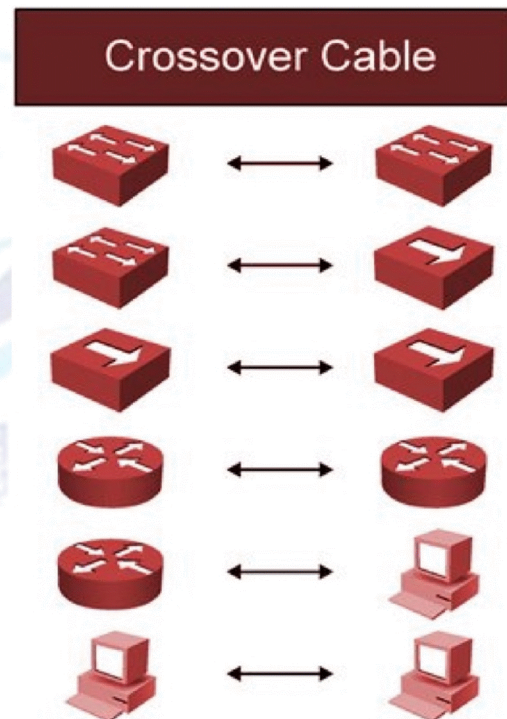


UTP cross cable color coding

White/orange	-	White/green
Orange	-	green
White/green	-	White/orange
Blue	-	Blue
White/blue	-	White/blue
Green	-	orange
White/brown	-	White/brown
Brown	-	brown

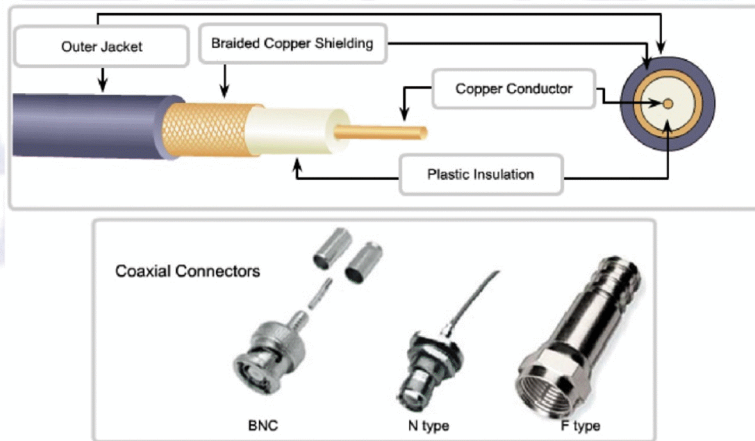
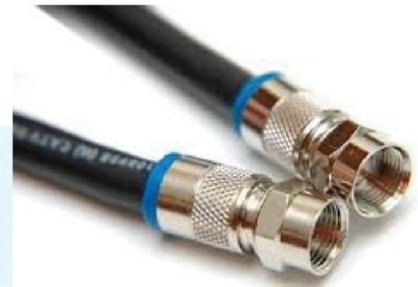


UTP cross cable used to connect between **similar devices**



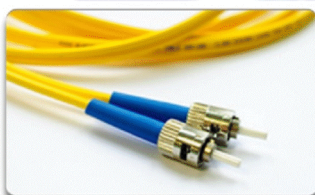
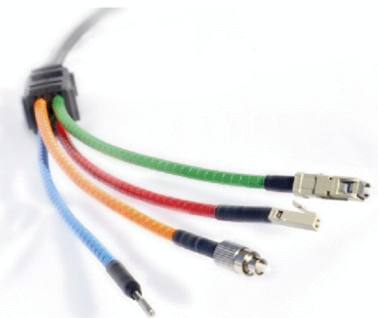
Co-axial Cable

- Commonly used in television
- Also used in LAN & WAN connections
- Supports distance in between 200 – 500 mts

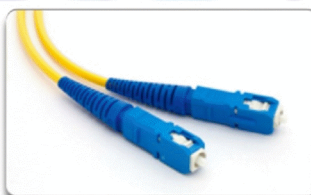


Fiber Cables

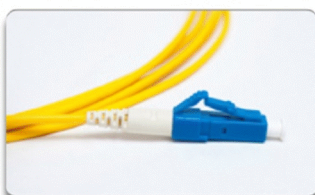
- Mostly used in WAN connections for longer distances.(2 – 60 Kms)
- Uses light signals
- Can send signals over longer distances and at higher bandwidths.



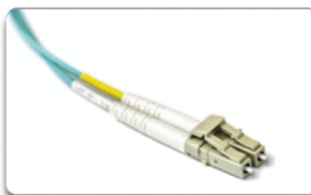
ST Connectors



SC Connectors



LC Connector



Duplex Multimode LC Connectors

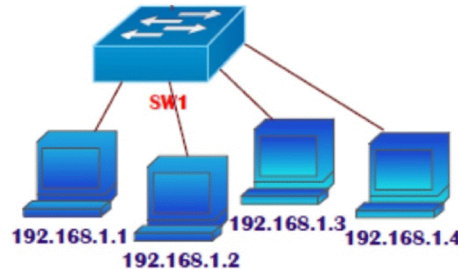
Wireless LAN

- ▶ Connecting devices within the LAN Without wire
- ▶ uses RF signals

Wi Fi



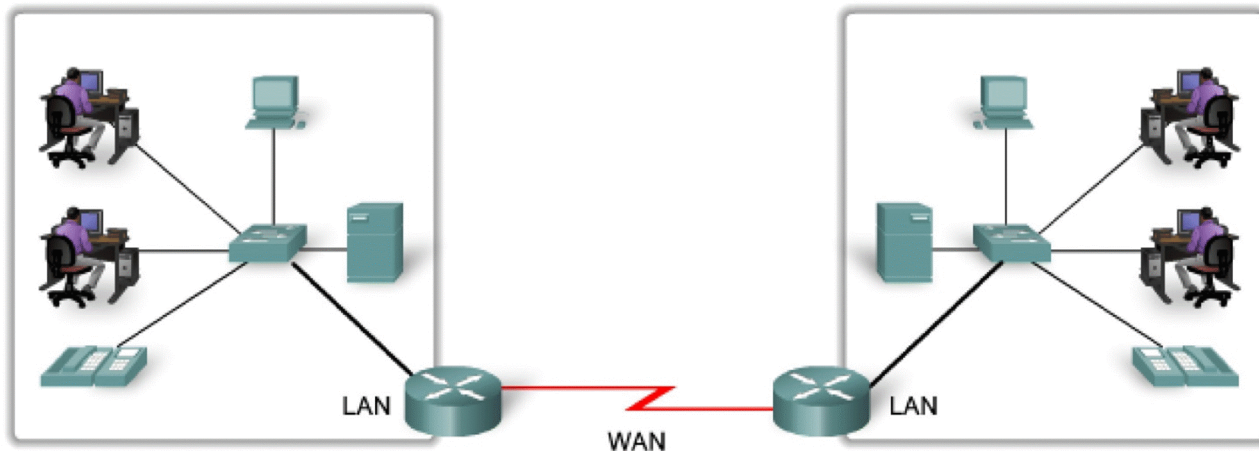
Basic LAN setup



- ▶ Connect 4 computers in the LAN using Switch
- ▶ Configure IP addressing on all PC using 192.168.1.0/24 network.
- ▶ Check Connectivity between all the PC using Ping command

Cisco Routers

Device connecting two or more LAN



Hyderabad

Bengaluru

Router Vendors in the market

Many companies are manufacturing Router :

- Cisco
- Juniper
- Nortel
- Multicom
- Cyclades
- Dlink
- Linksys
- 3Com

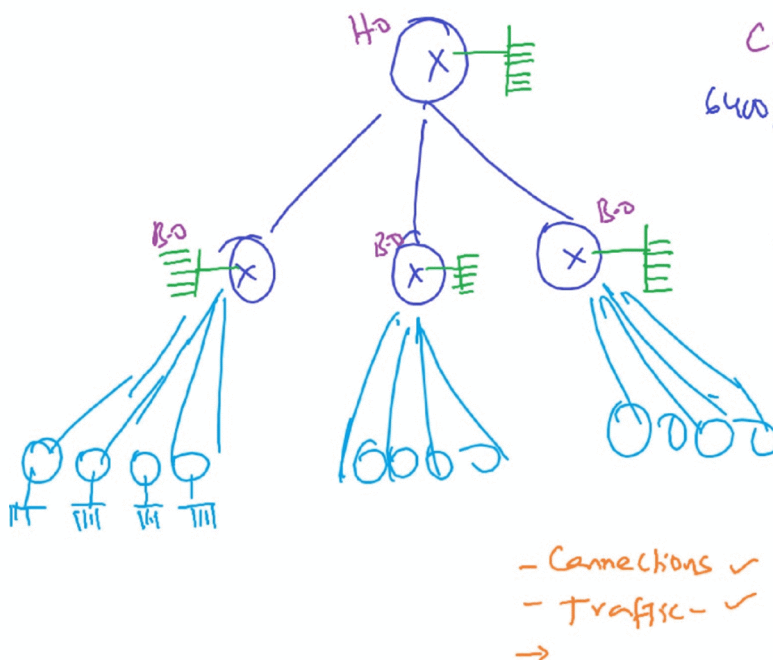


Cisco's Hierarchical Design Model

1. Access Layer Router
2. Distribution Layer Router
3. Core Layer Router



Cisco Hierarchal design



Access Layer Router

- ▶ Used at small end locations
- ▶ Can handle less traffic and less number of ports.

Router Series : 800, 1000, 1600,1700, 1800,1900,2500



Cisco 800



Cisco 1700



Cisco 1841



Distribution Layer Router

- ▶ Used at main branch offices and Head offices

Router Series : 2600, 2800,2900, 3200, 3600, 3700, 3800, 3900



Cisco 2900



Cisco 2801



Cisco 2811



Cisco 2821



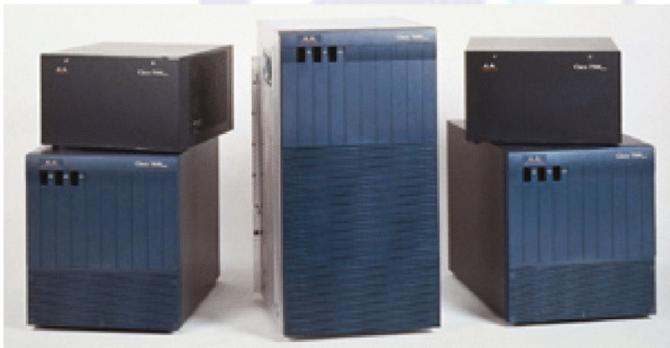
Cisco 2851

Cisco 2800 Series Integrated Services Routers

Core Layer Router

- ▶ Used by service providers and at main head offices.
- ▶ Processing traffic at very high speed .

Router Series : 6400, 7200, 7300, 7400, 7500, 7600, 10000, 12000



Cisco 7000



Cisco XR 12000 Series Routers

Router Classification

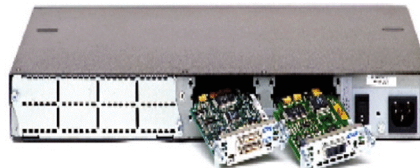
FIXED ROUTER

- All ports are integrated on motherboard (no Slots)
- Non Upgradable cannot add and remove the interfaces
- 2500, 800 series routers



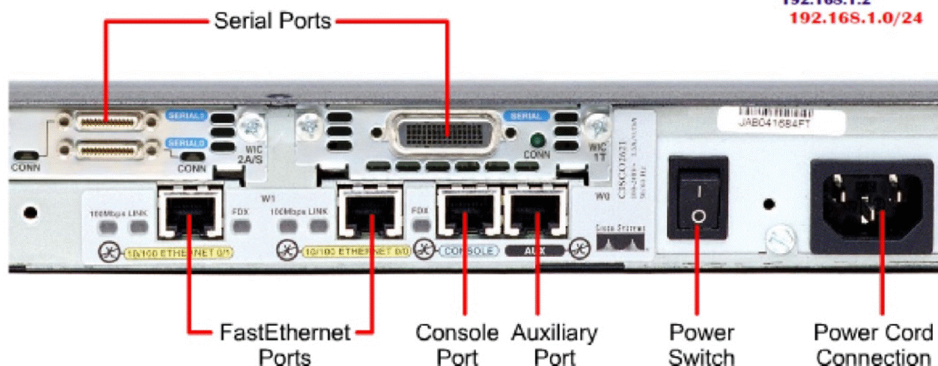
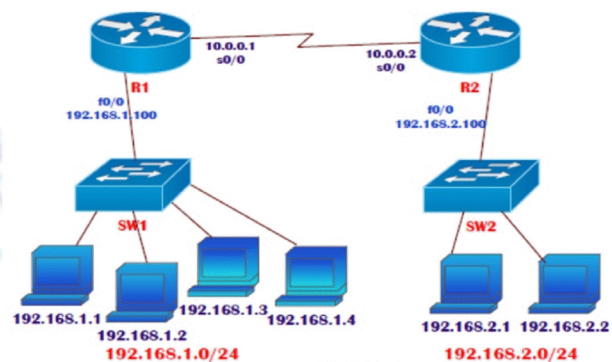
MODULAR ROUTER

- Have Slots where you can add or remove cards
- Distribution and Core Layer Routers
example of Modular Router
- 1600,1700,1800, 2600,2800,3600,3700



External Ports of Router

LAN , WAN , admin ports



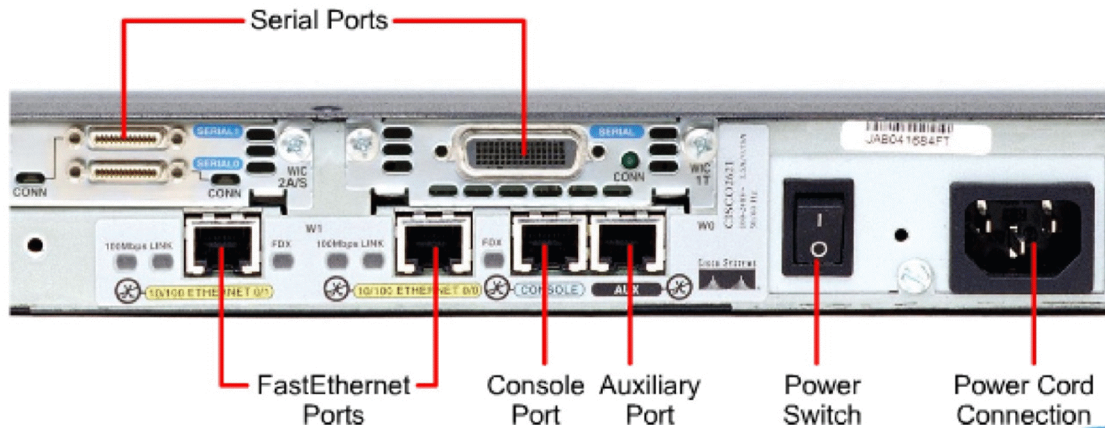
External Ports of Router

LAN Ports: (RJ45)

- Ethernet 10 Mbps
- Fast Ethernet 100 Mbps
- Gig Ethernet 1000 Mbps

WAN ports

- Serial ports
- 60 pin or 26 pin smart serial

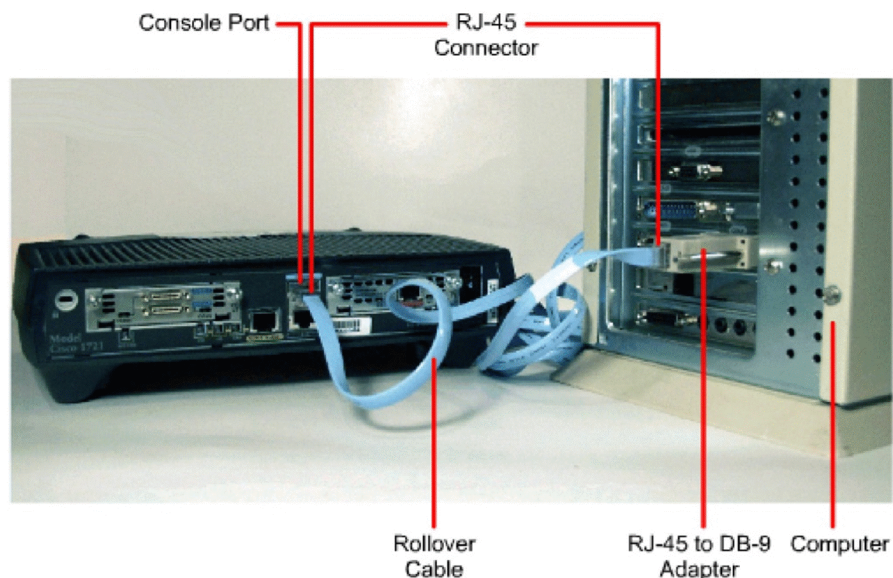


Console Port

- ▶ It is RJ45 Port
- ▶ Used for local administration ,Initial Configuration, Password Recovery.



Console Cable



HyperTerminal

Application used to see the Command line of a router via console

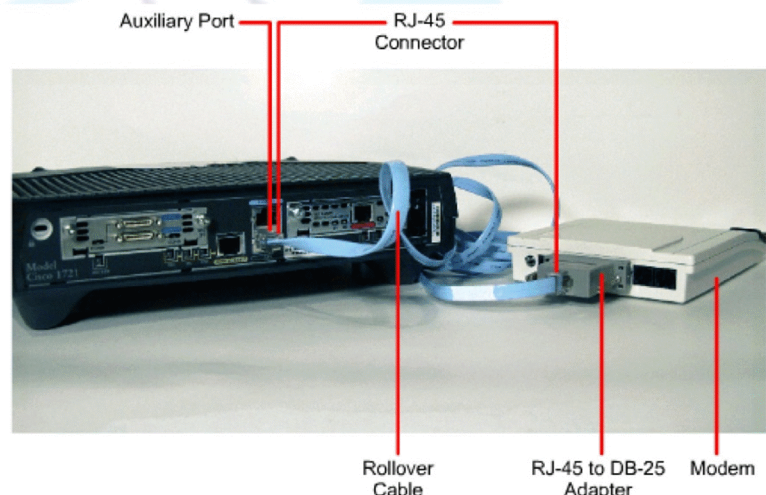
```
cisco_2621>en
Password:
cisco_2621#sh ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is 192.168.10.1 to network 0.0.0.0

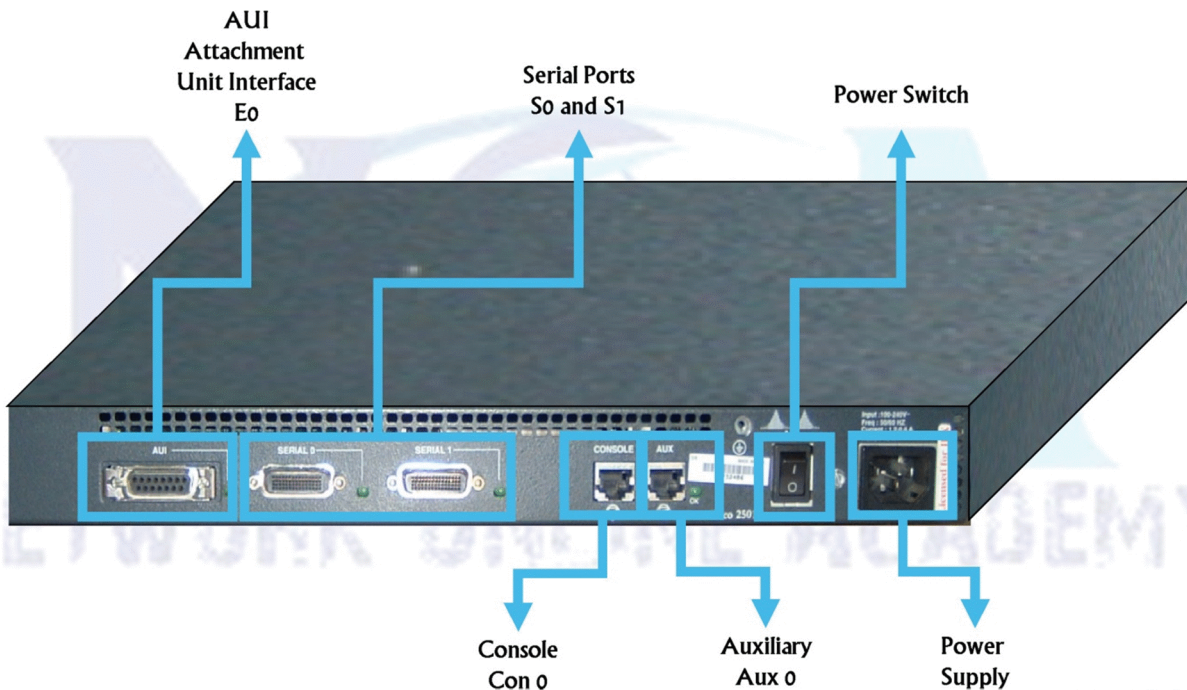
R    192.168.30.0/24 [120/1] via 192.168.20.1, 00:00:22, FastEthernet0/1
C    192.168.10.0/24 is directly connected, FastEthernet0/0
C    192.168.20.0/24 is directly connected, FastEthernet0/1
     10.0.0.0/24 is subnetted, 1 subnets
R       10.1.32.0 [120/1] via 192.168.10.1, 00:00:34, FastEthernet0/0
S*   0.0.0.0/0 [1/0] via 192.168.10.1
cisco_2621#
```

Auxiliary Port

- ▶ Its an RJ-45 port
- ▶ Used for remote administration.
- ▶ Uses the console cable connecting to modem



2500 Cisco router

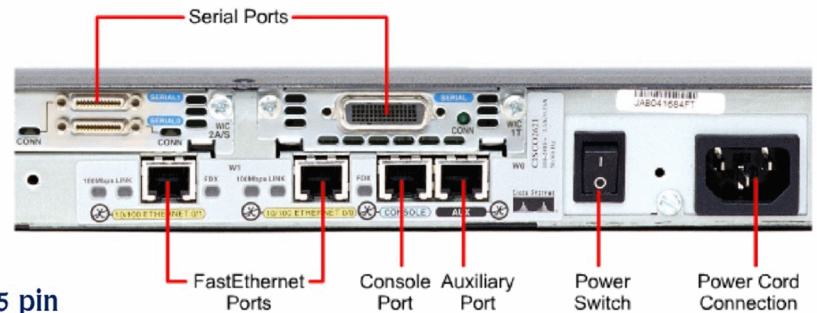


Attachment Unit Interface

- ▶ Commonly found on some old platforms (2500)
- ▶ AUI pin configuration is 15 pin port (Ethernet LAN using 15 Pin instead of RJ45)
- ▶ Transceiver is used for converting 8 wires to 15 wires. i.e. RJ45 to 15 pin converter.



Summary - External Ports of a Cisco Router



LAN interfaces - Ethernet

- AUI (Attachment Unit Interface) (E0)– 15 pin
- 10baseT – RJ45

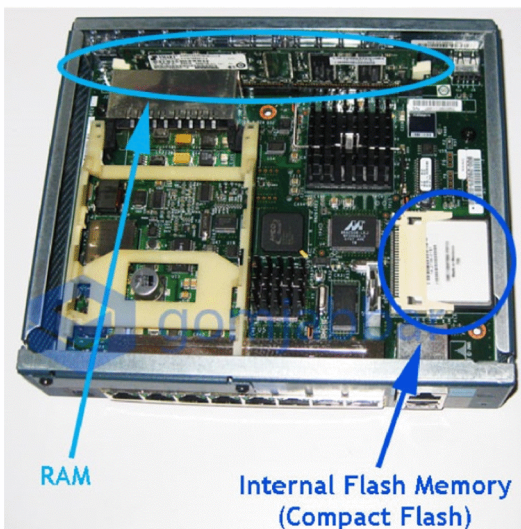
WAN interfaces

- Serial interface (S0, S1, s0/0, s0/1 , s0/0/0) – 60 pin/26 pin (smart serial)
- ISDN interface (BRI) – RJ45 (used for ISDN wan connections)

Administration interfaces

- Console – RJ45 – Local Administration
- Auxiliary – RJ45 – Remote Administration

Internal Components



ROM

loads the bootstrap programs and searches for the IOS (Flash/TFTP/ROM)

FLASH

Stores IOS

NVRAM

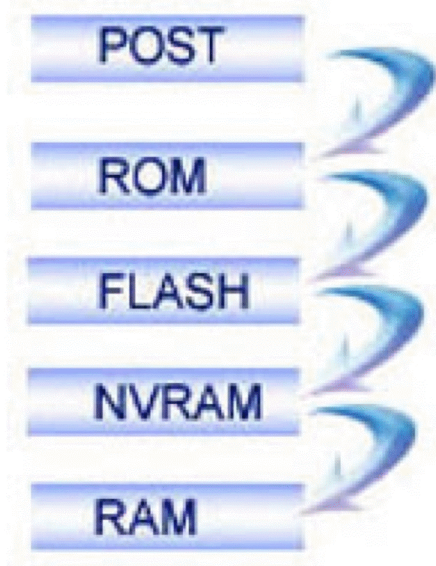
Stores configurations (permanent)
Startup-config

RAM

Stores Configurations (temporary)
Running-config



Booting process of cisco router



POST

power on self test Checks the hardware

ROM

loads the bootstrap programs and searches for the IOS (Flash/TFTP/ROM)

FLASH

Stores IOS

NVRAM

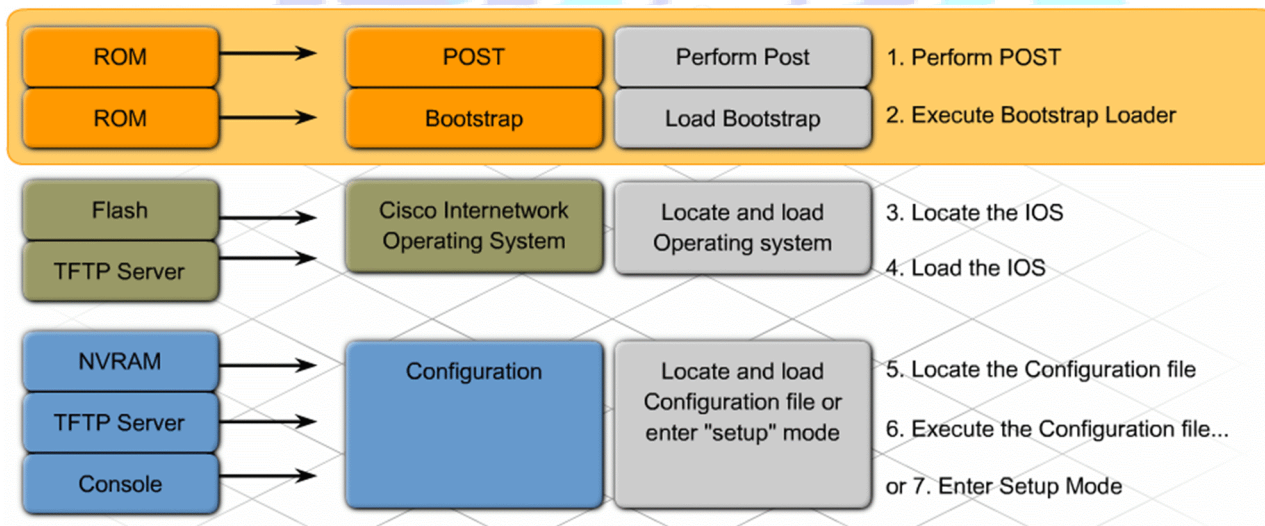
Stores configurations (permanent)

Startup-config

RAM

Stores Configurations (temporary)

Running-config



1. Performing the POST and Loading the Bootstrap Program

- The power-on self test (POST) is a process that occurs on almost every computer when it boots. The POST is used to test the router hardware.
- After the POST, the bootstrap program is loaded. The bootstrap program locates the Cisco IOS and loads it into RAM.

2. Locating and Loading the IOS Software

The location of the IOS file is specified by the value of the configuration register setting. The bits in this setting can instruct the device to load the IOS file from the following locations:

- Flash memory
- A TFTP server
- To load the IOS normally from flash, the configuration register setting should be set to 0x2102.

3. Locating and Executing the Startup Configuration File or Entering Setup Mode

- After the IOS is loaded, the bootstrap program searches for the startup configuration file (startup-config) in NVRAM.
- This file contains the previously saved configuration commands and parameters, including Interface addresses, Routing information, Passwords, other configuration parameters
- If no configuration file is located, the router prompts the user to enter setup mode to begin the configuration process.
- If a startup configuration file is found, a prompt containing a hostname will display. The router has successfully loaded the IOS and the configuration file.

Integrated Services Router (ISR).

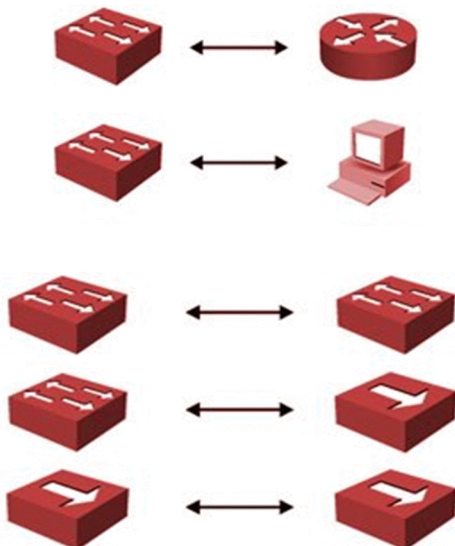
- It gets its name because many of the services, like security, are built into it. It's a modular device like the 2600,
- but it's much faster and a lot more sleek—it's elegantly designed to support a broad new range of interface options.

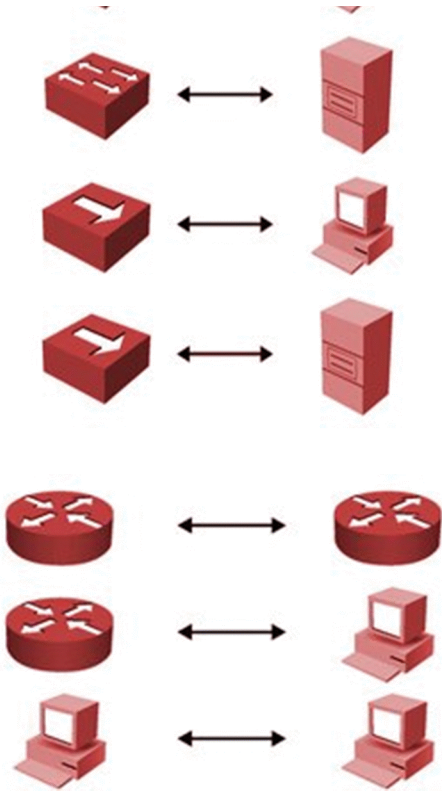
800,1800,2800,3800, 1900,2900,3900,

Test your skills :

What is the color –coding for straight and cross cables.

Identify the correct cable used for physical connections in the LAN.





What is the difference between fixed and modular routers?

List the series of ISR routers?

What are the common external ports on cisco routers?

What is use of console & Auxiliary ports?

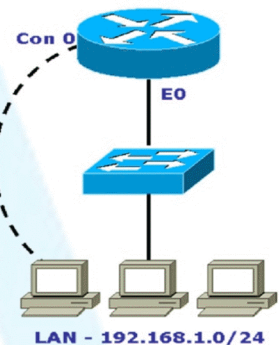
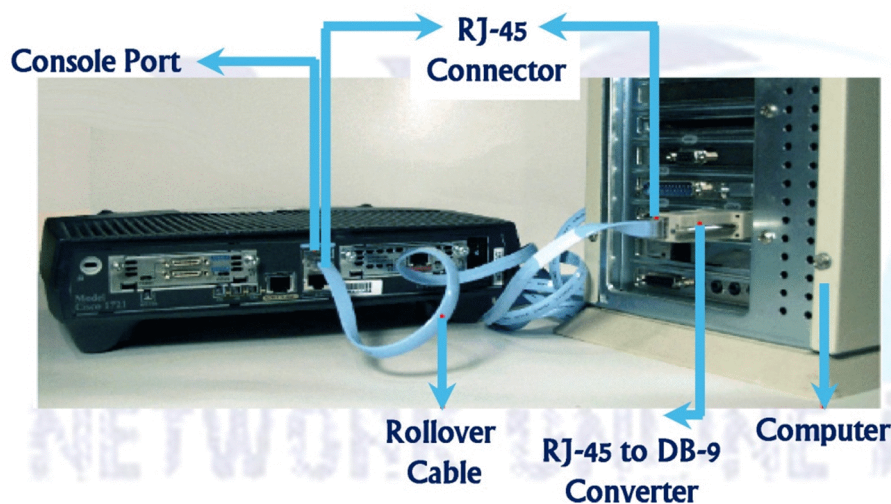
Explain the booting process on cisco routers?

Basic commands on Cisco Routers

Router Modes, Assign Passwords

NETWORK ONLINE ACADEMY

Console Connectivity using Com (Rs232) port



Console Connectivity using COM- USB port on Laptops

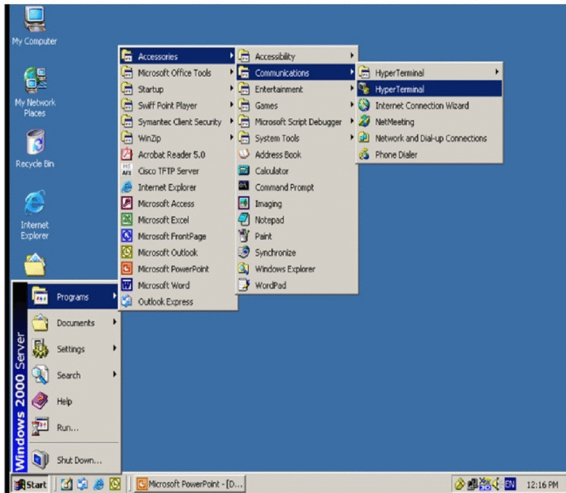


Terminal Emulation Programs

Software available for connecting to a networking device.

- ▶ HyperTerminal
- ▶ PuTTY
- ▶ Tera Term
- ▶ SecureCRT
- ▶ OS X Terminal

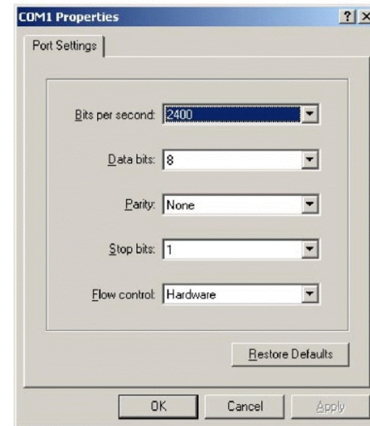
HyperTerminal for console access



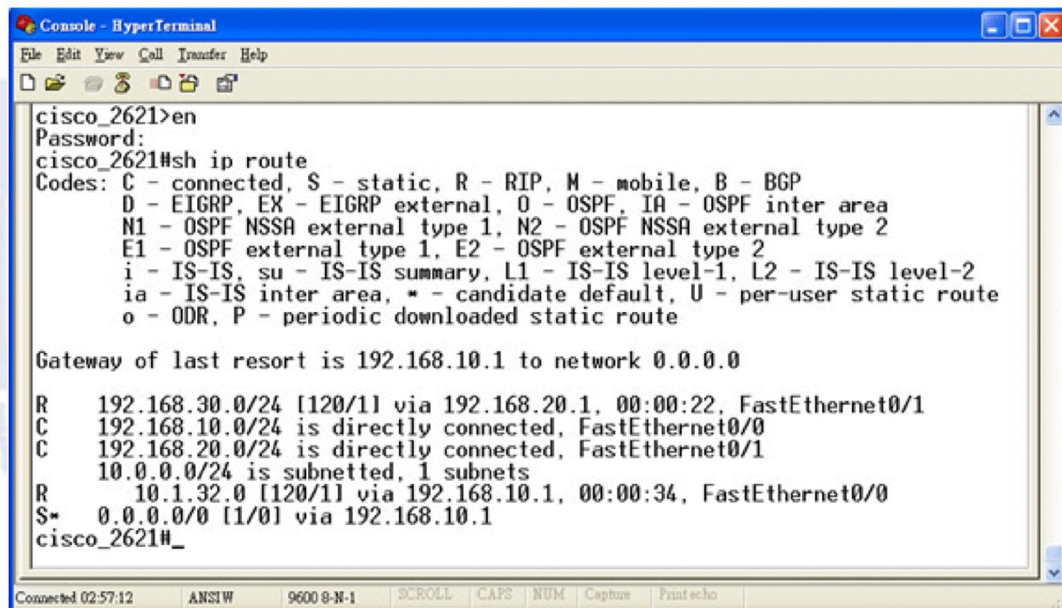
(1) Connection Description



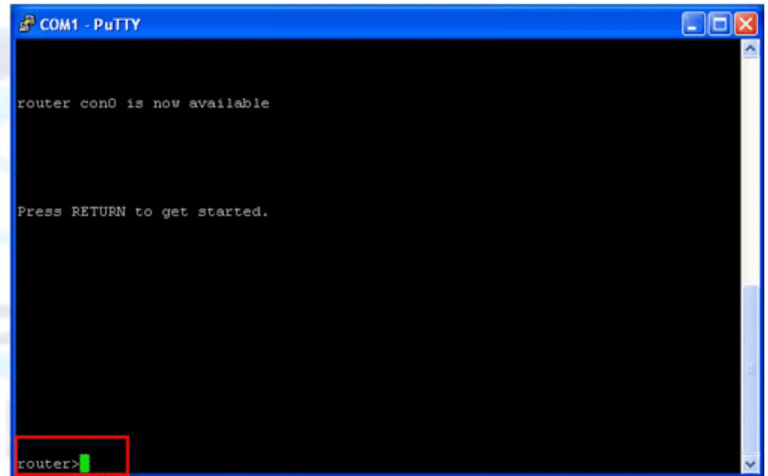
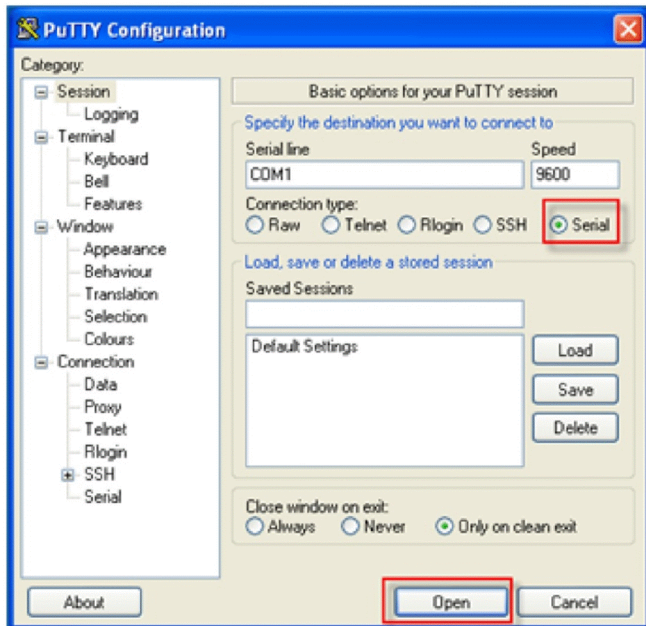
(2) Connect To



HyperTerminal for console access



Putty Software for Console access of router



IOS Mode Hierarchical Structure

User EXEC Command-Router>

ping
show (limited)
enable
etc.

Privileged EXEC Commands-Router#

all User EXEC commands
debug commands
reload
configure
etc.

Global Configuration Commands-Router (config) #

hostname
enable secret
ip route

interface ethernet
serial
dsl
etc.

Interface Commands-Router (config-if) #

ip address
ipv6 address
encapsulation
shutdown/ no shutdown
etc.

router rip
ospf
eigrp
etc.

Routing Engine Commands-Router (config-router) #

network
version
auto summary
etc.

line vty
console
etc.

Line Commands-Router (config-line) #

password
login
modem commands
etc.

Modes on Cisco Routers

Setup Mode :-

- If NVRAM is Blank

User Mode:-

- Only some basic monitoring

Privileged Mode:-

- monitoring and some troubleshooting

Global Configuration mode:-

- All Configurations that effect the router globally

Interface mode:-

- Configurations done on the specific interface

Rommon Mode:-

- Reverting Password

Setup Mode

- ▶ If NVRAM is blank (router without configurations)
- ▶ new router or erase startup-configurations
- ▶ Skip setup mode using No option

```
Cisco 1841 (revision 5.0) with 114688K/16384K bytes of memory.
Processor board ID FTX0947Z18E
M860 processor: part number 0, mask 49
2 FastEthernet/IEEE 802.3 interface(s)
191K bytes of NVRAM.
63488K bytes of ATA CompactFlash (Read/Write)
Cisco IOS Software, 1841 Software (C1841-ADVIPSERVICESK9-M), Version 12.4(15)T1,
RELEASE SOFTWARE (fc2)
Technical Support: http://www.cisco.com/techsupport
Copyright (c) 1986-2007 by Cisco Systems, Inc.
Compiled Wed 18-Jul-07 04:52 by pt_team
```

--- System Configuration Dialog ---

```
Continue with configuration dialog? [yes/no]:
% Please answer 'yes' or 'no'.
Continue with configuration dialog? [yes/no]:
```

User Mode: Only some basic monitoring

Router>

Router>show flash

System flash directory:

File	Length	Name/status
3	5571584	c2600-i-mz.122-28.bin

[5827403 bytes used, 58188981 available, 64016384 total]

63488K bytes of processor board System flash (Read/Write)

Router>sh ip interface brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	unassigned	YES	unset	administratively down	down
FastEthernet0/1	unassigned	YES	unset	administratively down	down'

Router>show version

Cisco Internetwork Operating System Software

IOS (tm) C2600 Software (C2600-I-M), Version 12.2(28), RELEASE SOFTWARE (fc5)

Technical Support: <http://www.cisco.com/techsupport>

Copyright (c) 1986-2005 by cisco Systems, Inc.

Compiled Wed 27-Apr-04 19:01 by miwang

Image text-base: 0x8000808C, data-base: 0x80A1FECC

ROM: System Bootstrap, **Version 12.1(3r)T2**, RELEASE SOFTWARE (fc1)

Copyright (c) 2000 by cisco Systems, Inc.

ROM: **C2600 Software** (C2600-I-M), Version 12.2(28), RELEASE SOFTWARE (fc5)

System returned to ROM by reload

System image file is **"flash:c2600-i-mz.122-28.bin"**

cisco 2621 (MPC860) processor (revision 0x200) with **60416K/5120K** bytes of memory

Processor board ID JAD05190MTZ (4292891495)

M860 processor: part number 0, mask 49

Bridging software.

X.25 software, Version 3.0.0.

2 FastEthernet/IEEE 802.3 interface(s)

32K bytes of non-volatile configuration memory.

63488K bytes of ATA CompactFlash (Read/Write)

Configuration register is 0x2102

Router>ping 1.1.1.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 1.1.1.1, timeout is 2 seconds:

.....

Success rate is 0 percent (0/3)

Router>traceroute 1.1.1.1

Type escape sequence to abort.

Tracing the route to 1.1.1.1

Privilege Mode

- ▶ Complete monitoring
- ▶ All show commands, Copy , erase commands

Router> **enable**

Router #

Router # **show flash**

Router # **show version**

Router # **show ip interface brief**

Router# **ping 1.1.1.1**

Router # **traceroute 50.1.1.1**

Router # **show running-config** (configs in RAM)

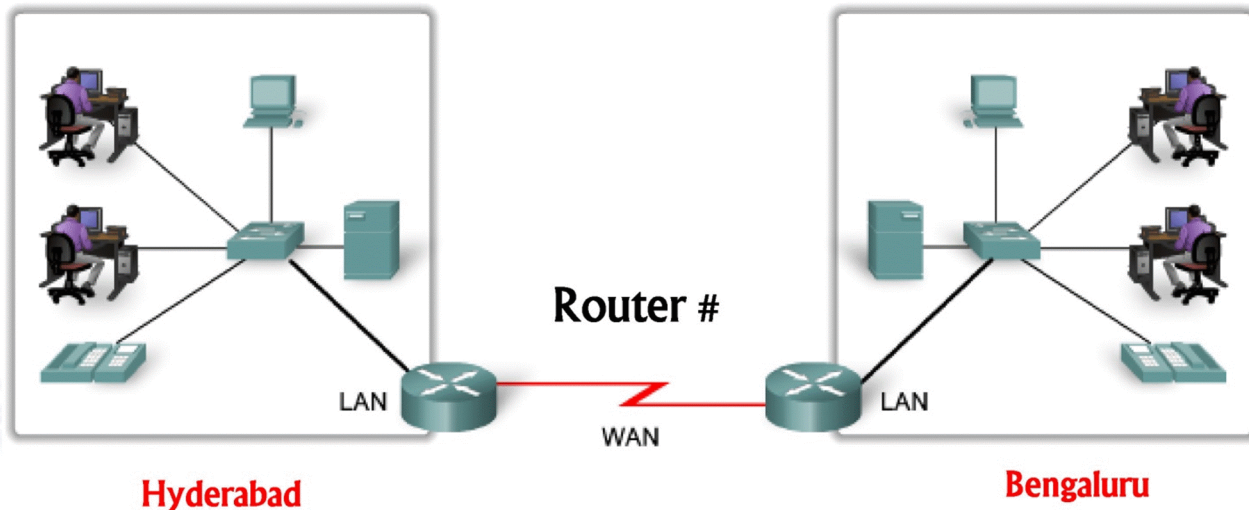
Router # **show startup-config** (configs in NVRAM)

Router # **Copy** (save configurations)

Router # **erase** (erase configurations)

Changing Hostnames

Without names, network devices are difficult to identify for configuration purposes.



Global configuration mode

Router #

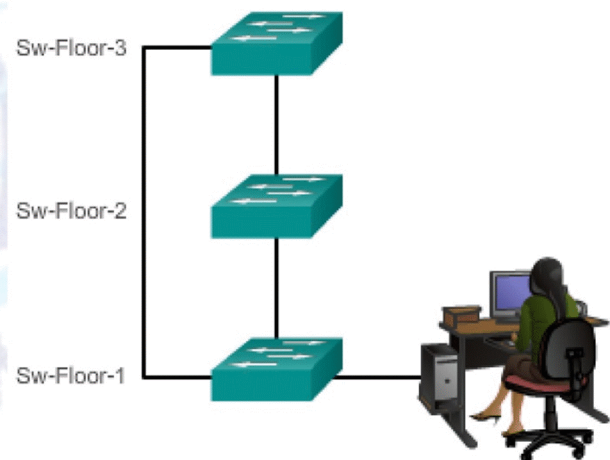
Router # **configure terminal**

Router (config) #

Router (config) # **hostname NOA**

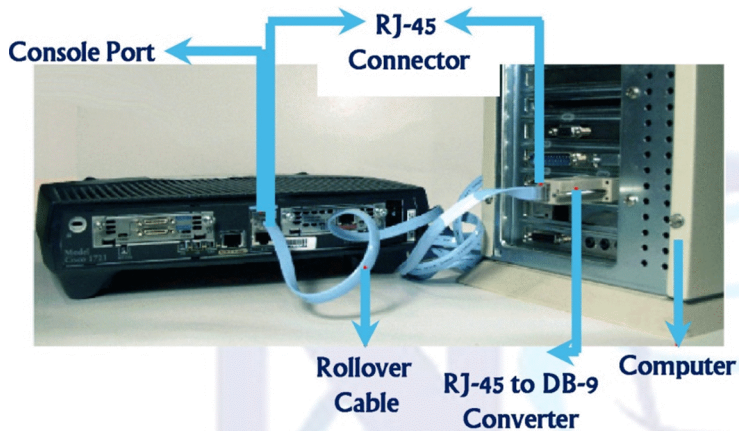
NOA (config) #

Configuring Device Names

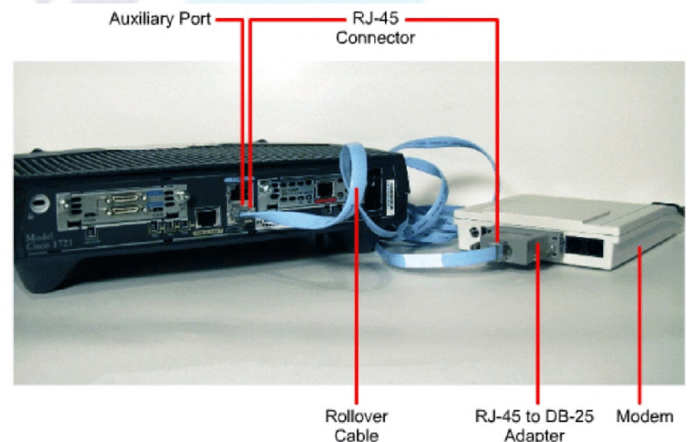


Hostnames allow devices to be identified by network administrators over a network

Assigning Passwords

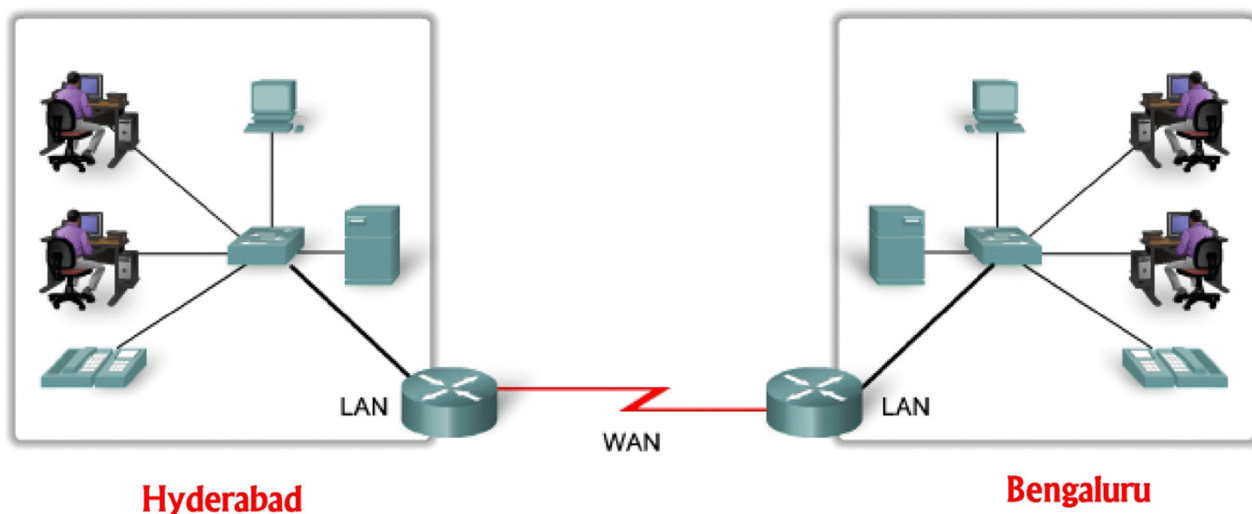


- ▶ Console
- ▶ Auxiliary
- ▶ VTY line (telnet)



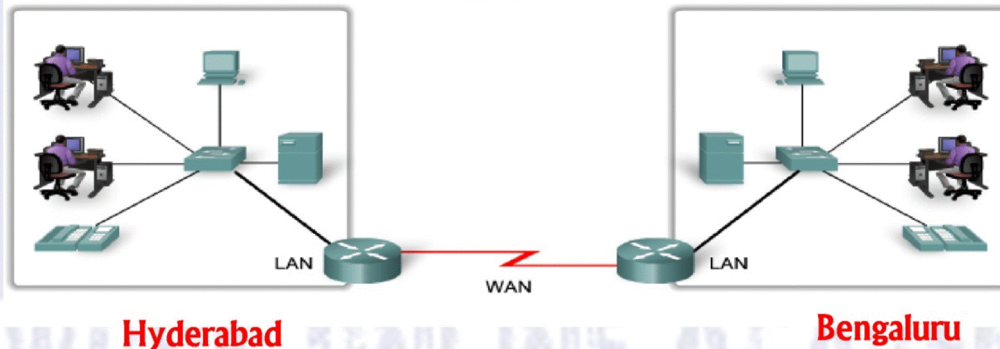
Using VTY line for Telnet

- Telnet protocol allow you to access remote device .
- Telnet uses VTY line on cisco devices



Prerequisite for Telnet access

- ▶ Connectivity
- ▶ IP address
- ▶ VTY line must be configured with passwords.



NOTE:

we can verify telnet practically once we cover some topics relating to connectivity and IP addressing

Assigning console password:

```
Router(config) # line con 0
Router(config-line) # password <password> (line mode)
Router(config-line) # login
Router(config-line) # exit
```

Assigning Auxiliary password:

```
Router(config) # line aux 0
Router(config-line) # password <password>
Router(config-line) # login (line mode)
Router(config-line) # exit
```

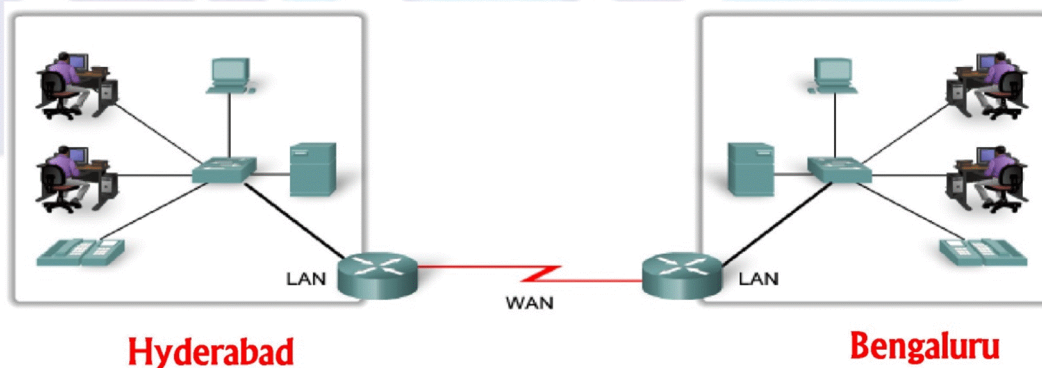

Assigning Telnet password:

Router(config) # **line vty 0 4**

Router(config-line) # **password <password>** (line mode)

Router(config-line) # **login**

Router(config-line) # **exit**



Enable Password

Router> **enable**

Router #

Router> **enable**

Password:

Router #

Router(config) # **enable password <password>**

The password will be saved in clear text

OR

Router(config) # **enable secret <password>**

The password will be saved in encrypted text

Encrypting all Password Display

```
(config)# service password-encryption
```

Banner Messages

```
(config)# banner motd # ..... #
```

Limiting Device Access - MOTD Banner

```
LAB_A(config)#banner motd # This is a secure system. Authorized Access ONLY!!! #
```

This configuration results in this message of the day banner.

Delimiting characters are not included in the message.

```
Sw1-Floor-1 con0 is now available
Press RETURN to get started.
This is a secure system. Authorized
Access ONLY!!!
User Access Verification
password:
Sw1-Floor-1>enable
Password:
Sw1-Floor-1#
```


To save the configuration:

Router # **copy running-config startup-config**

(OR)

Router # **write memory**

(OR)

Router # **write**

Erase all Configurations

NOA # **erase startup-config**

NOA # **reload**

LAB: BASIC CONFIGURATIONS AND VERIFICATIONS

TASK:

Connect the router via Console cable on console port (as per diagram)

POWER on the router and observe the booting Process (sample Output shown below)

System Bootstrap, Version 12.1(3r)T2, RELEASE SOFTWARE (fc1)
Copyright (c) 2000 by cisco Systems, Inc.
cisco 2621 (MPC860) processor (revision 0x200) with 60416K/5120K bytes of memory

Self decompressing the image:

[OK]

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Rights clause at FAR sec. 52.227-19 and subparagraph
(c) (1) (ii) of the Rights in Technical Data and Computer
Software clause at DFARS sec. 252.227-7013.

cisco Systems, Inc.
170 West Tasman Drive
San Jose, California 95134-1706

Cisco Internetwork Operating System Software
IOS (tm) C2600 Software (C2600-I-M), Version 12.2(28), RELEASE SOFTWARE (fc5)
Technical Support: <http://www.cisco.com/techsupport>
Copyright (c) 1986-2005 by cisco Systems, Inc.
Compiled Wed 27-Apr-04 19:01 by miwang

cisco 2621 (MPC860) processor (revision 0x200) with 60416K/5120K bytes of memory

.
Processor board ID JAD05190MTZ (4292891495)
M860 processor: part number 0, mask 49
Bridging software.
X.25 software, Version 3.0.0.

2 FastEthernet/IEEE 802.3 interface(s)
32K bytes of non-volatile configuration memory.
63488K bytes of ATA CompactFlash (Read/Write)

--- System Configuration Dialog ---

Continue with configuration dialog? [yes/no]:
% Please answer 'yes' or 'no'.
Continue with configuration dialog? [yes/no]: no

Press RETURN to get started!

Router>

Router>show flash

System flash directory:
File Length Name/status
3 5571584 c2600-i-mz.122-28.bin
[5827403 bytes used, 58188981 available, 64016384 total]
63488K bytes of processor board System flash (Read/Write)

Router>show version

Cisco Internetwork Operating System Software
IOS (tm) C2600 Software (C2600-I-M), Version 12.2(28), RELEASE SOFTWARE (fc5)
Technical Support: <http://www.cisco.com/techsupport>
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Compiled Wed 27-Apr-04 19:01 by miwang
Image text-base: 0x8000808C, data-base: 0x80A1FECC

ROM: System Bootstrap, Version 12.1(3r)T2, RELEASE SOFTWARE (fc1)
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ROM: C2600 Software (C2600-I-M), Version 12.2(28), RELEASE SOFTWARE (fc5)

System returned to ROM by reload
System image file is "flash:c2600-i-mz.122-28.bin"

cisco 2621 (MPC860) processor (revision 0x200) with 60416K/5120K bytes of memory

.
Processor board ID JAD05190MTZ (4292891495)
M860 processor: part number 0, mask 49
Bridging software.
X.25 software, Version 3.0.0.

2 FastEthernet/IEEE 802.3 interface(s)
32K bytes of non-volatile configuration memory.
63488K bytes of ATA CompactFlash (Read/Write)
Configuration register is 0x2102

Router>sh ip interface brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	unassigned	YES	unset	administratively down	down
FastEthernet0/1	unassigned	YES	unset	administratively down	down

Router>ping 1.1.1.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 1.1.1.1, timeout is 2 seconds:

.....

Success rate is 0 percent (0/3)

Router>traceroute 1.1.1.1

Type escape sequence to abort.

Tracing the route to 1.1.1.1

To enter in to privilege mode

Router> **enable**

By typing the clock ?command, you'll get a list of the next possible parameters and what they do. Notice that you should just keep typing a command, a space, and then a question mark until <cr> (carriage return) is your only option.

If you're typing commands and receive

To enter in to privilege mode

Router# **configure terminal**

Enter configuration commands, one per line. End with CNTL/Z.

TO change the Hostname of the router

Router(config)# **hostname HYDERABAD**

HYDERABAD (config)#

TO ASSIGN CONSOLE PASSWORD

HYDERABAD(config)#line console 0

HYDERABAD(config-line)#password **cisco123**

HYDERABAD(config-line)#login

HYDERABAD(config-line)#end

HYDERABAD#

%SYS-5-CONFIG_I: Configured from console by console

HYDERABAD# exit

HYDERABAD con0 is now available

Press RETURN to get started.

User Access Verification

Password:

(Enter the console password which was configured)

HYDERABAD>

HYDERABAD>enable

HYDERABAD# conf terminal

Enter configuration commands, one per line. End with CNTL/Z.

HYDERABAD(config)# line vty 0 4


```
HYDERABAD(config-line)# password ccna123
```

```
HYDERABAD(config-line)# login
```

```
HYDERABAD(config-line)# exit
```

```
HYDERABAD(config)# enable password ccnp123
```

```
HYDERABAD(config)# exit
```

```
HYDERABAD# exit
```

HYDERABAD con0 is now available
Press RETURN to get started.

User Access Verification

Password:

(Enter the console password which was configured)

```
HYDERABAD> enable
```

Password:

(Enter the enable password which was configured)

```
HYDERABAD#
```

```
HYDERABAD# show running-config
```

```
Building configuration...
```

```
Current configuration : 480 bytes
```

```
!
```

```
version 12.2
```

```
no service timestamps log datetime msec
```

```
no service timestamps debug datetime msec
```

```
no service password-encryption
```

```
!
```

```
hostname HYDERABAD
```

```
!
```

```
!
```

```
!
```

```
enable password ccnp123
```

```
!
```

```
!
```

```
!
```

```
!
```

```
HYDERABAD# configure terminal
```

```
HYDERABAD(config)# enable secret ccie123
```

```
HYDERABAD(config)# exit
```

HYDERABAD# show running-config

Building configuration...

Current configuration : 527 bytes

!

version 12.2

no service timestamps log datetime msec

no service timestamps debug datetime msec

no service password-encryption

!

hostname HYDERABAD

!

!

!

enable secret 5 \$1\$mERr\$2ft7pDdq4XzRIT3Dy74gx/

enable password ccnp123

!

HYDERABAD# erase startup-config

Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]

[OK]

Erase of nvram: complete

HYDERABAD# reload

Proceed with reload? [confirm]

%SYS-5-RELOAD: Reload requested by console. Reload Reason: Reload Command.

System Bootstrap, Version 12.1(3r)T2, RELEASE SOFTWARE (fc1)

Copyright (c) 2000 by cisco Systems, Inc.

cisco 2621 (MPC860) processor (revision 0x200) with 60416K/5120K bytes of memory

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Processor board ID JAD05190MTZ (4292891495)

M860 processor: part number 0, mask 49

Bridging software.

X.25 software, Version 3.0.0.

2 FastEthernet/IEEE 802.3 interface(s)

32K bytes of non-volatile configuration memory.

63488K bytes of ATA CompactFlash (Read/Write)

--- System Configuration Dialog ---

Continue with configuration dialog? [yes/no]:

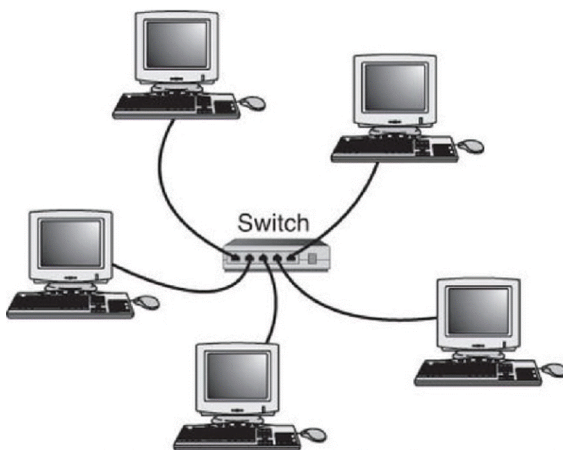
NOTE: The router enters in to setup mode as the startup-config been erased



Inter-connecting devices LAN & WAN

Cisco Switch

Provides centralized location to connect devices with in the LAN.



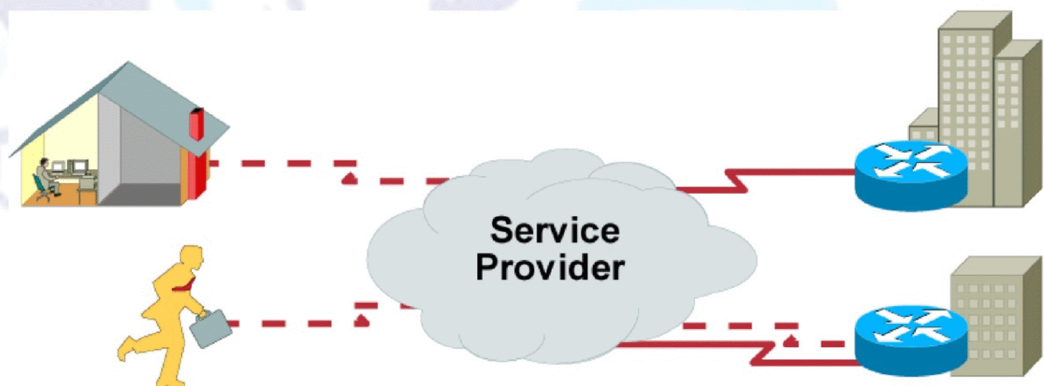
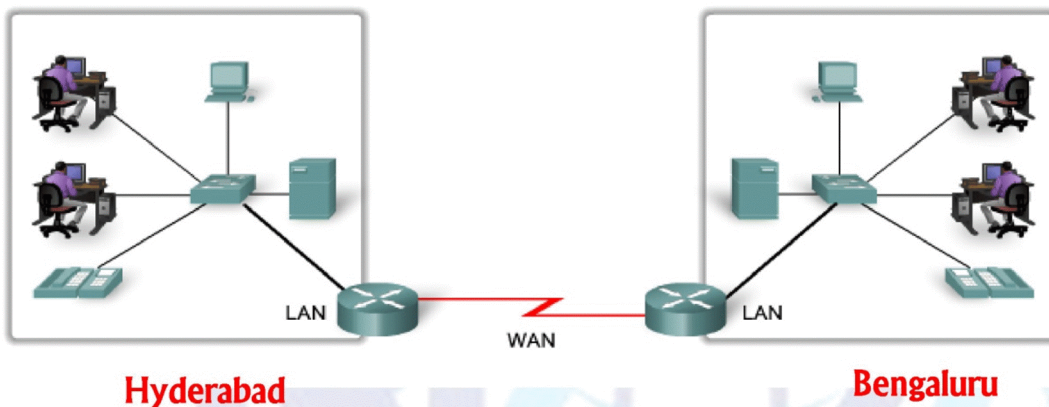
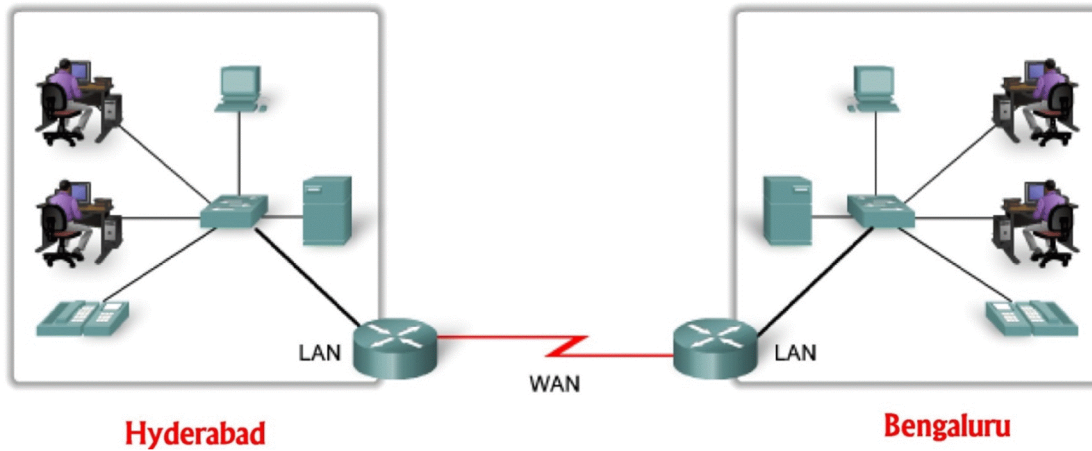
Switch



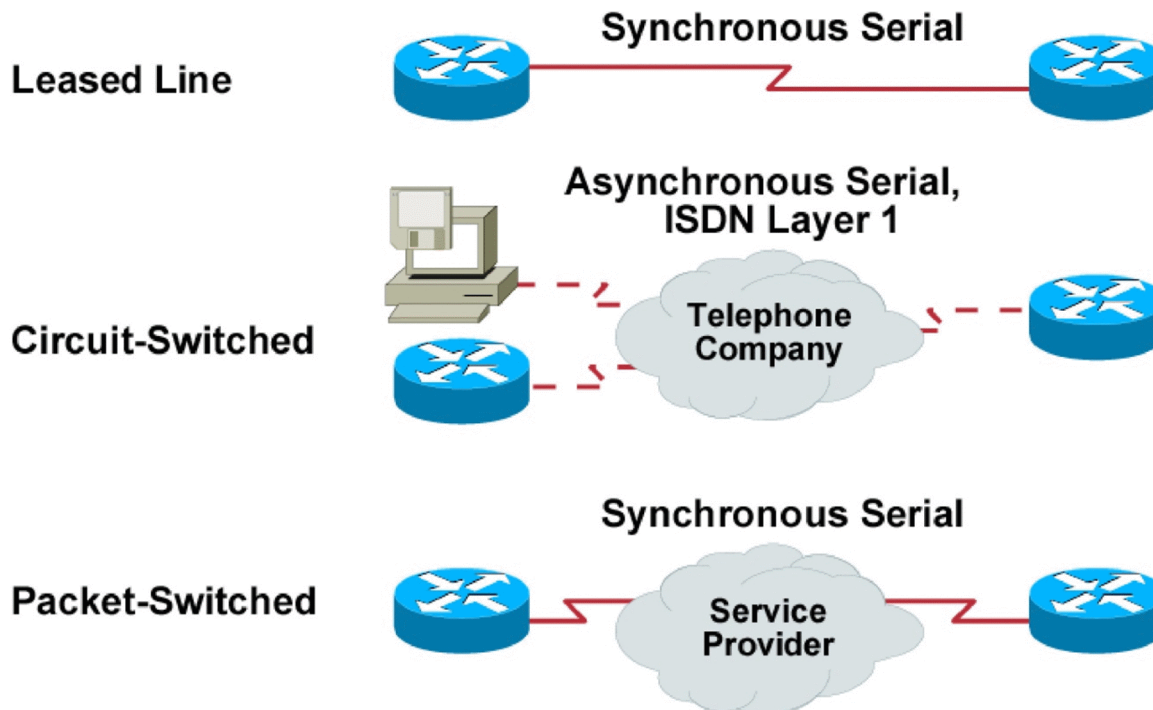
Rj45 Cable

Cisco Routers

Device connecting two or more LAN



WAN Connection Types

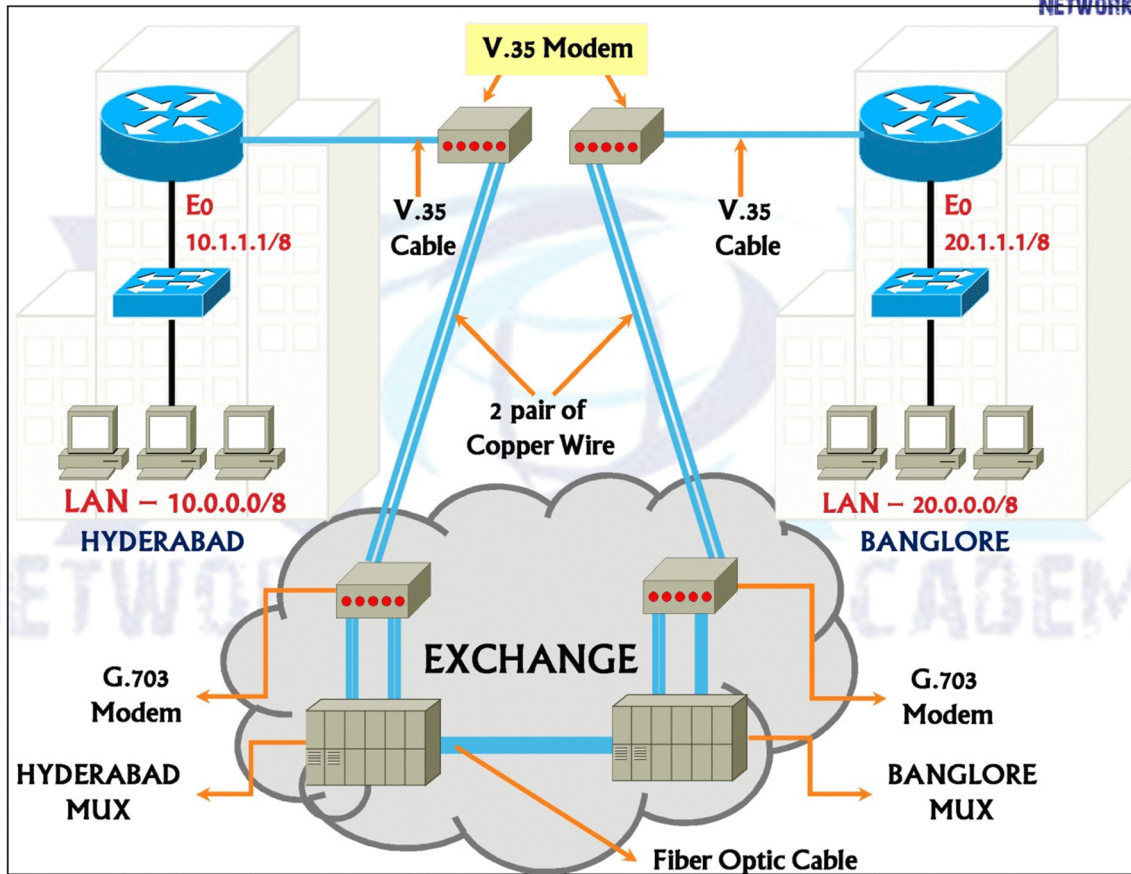


Modern WAN Connections

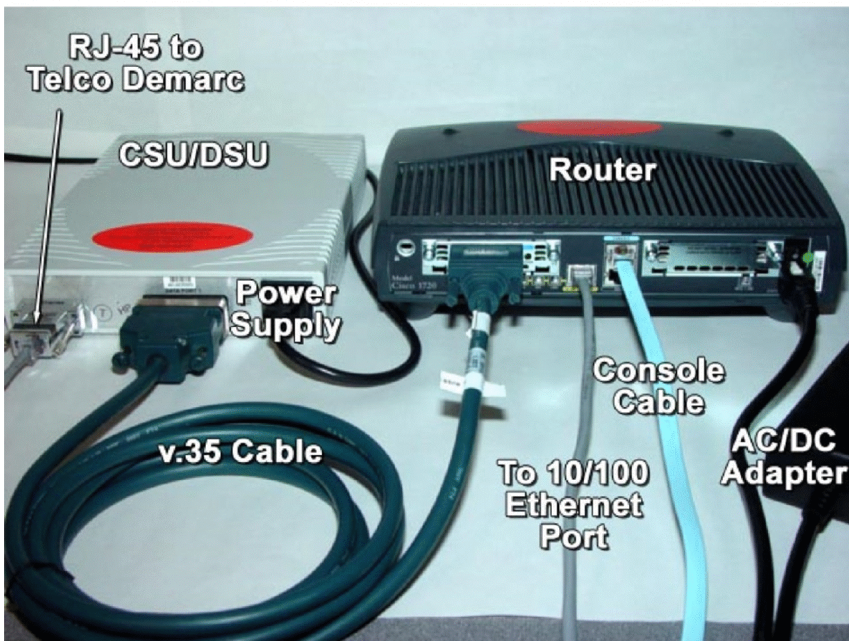
- ▶ MPLS
- ▶ Metro Ethernet
- ▶ Virtual Private Network (VPN)
- ▶ DSL
- ▶ Cable
- ▶ VSAT

More on these Technologies will be discussed in WAN Technologies

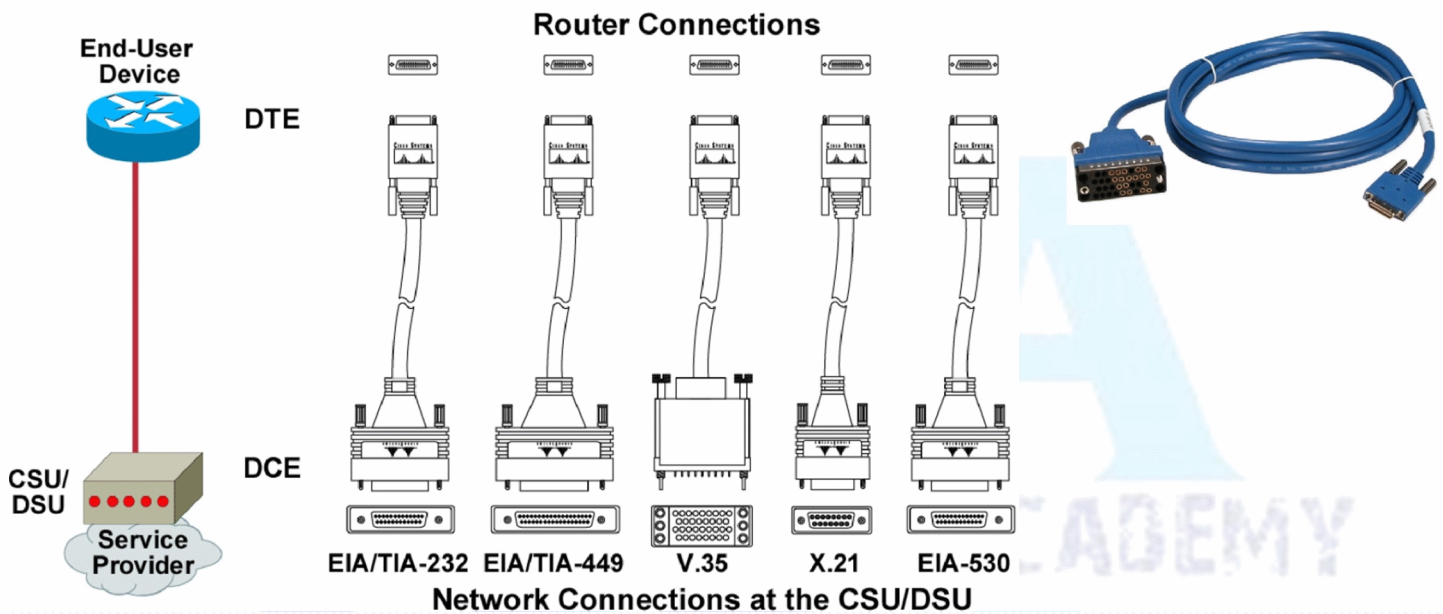
Leased Lines



V.35 modems & Cable



Serial Point-to-Point Connections



Network Connections at the CSU/DSU

DTE

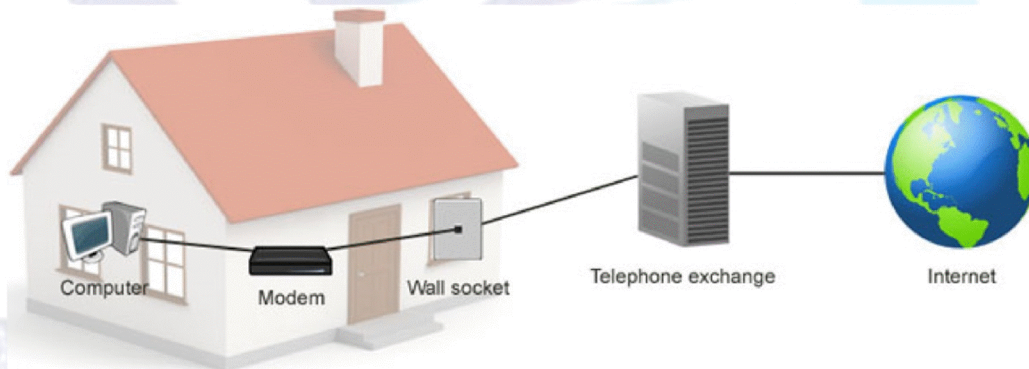
1. Data Termination Equipment
2. Accept clocking (i.e. Speed).
3. Example of DTE device in Leased line setup : Router
4. Example of DTE device in Dial up setup : Computer

DCE

1. Data Communication Equipment
2. Generate clocking (i.e. Speed).
3. Example of DCE device in Leased line setup : V.35 & G.703 Modem & Exchange (Modem & MUX)
4. Example of DCE device in Dial up setup : Dialup Modem

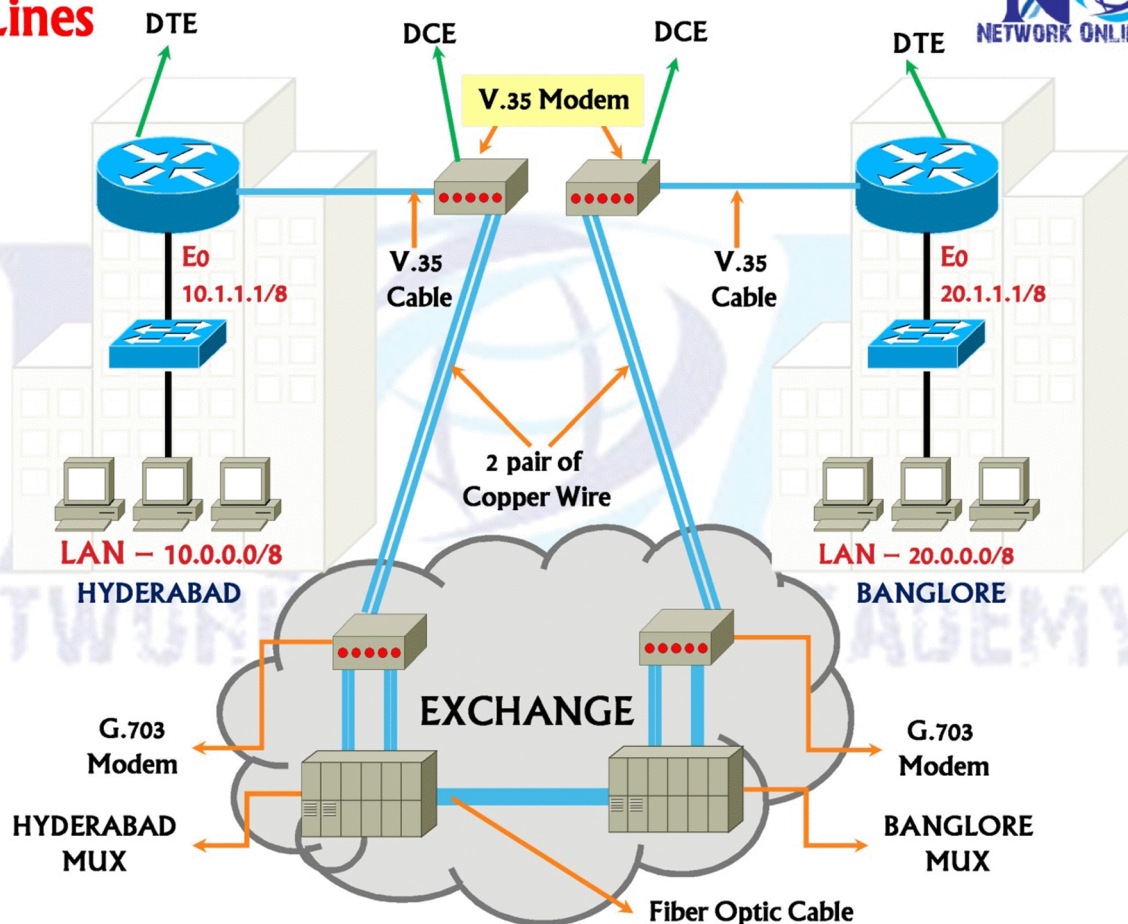
Dial-up Internet access over Telco

Computer – DTE

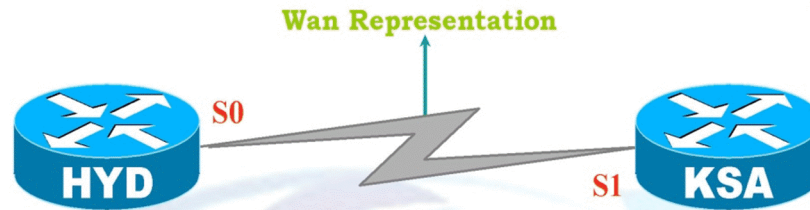


Modem - DTE

Leased Lines

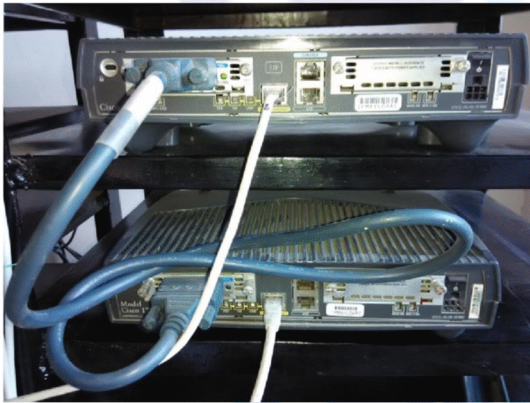


Lab Setup

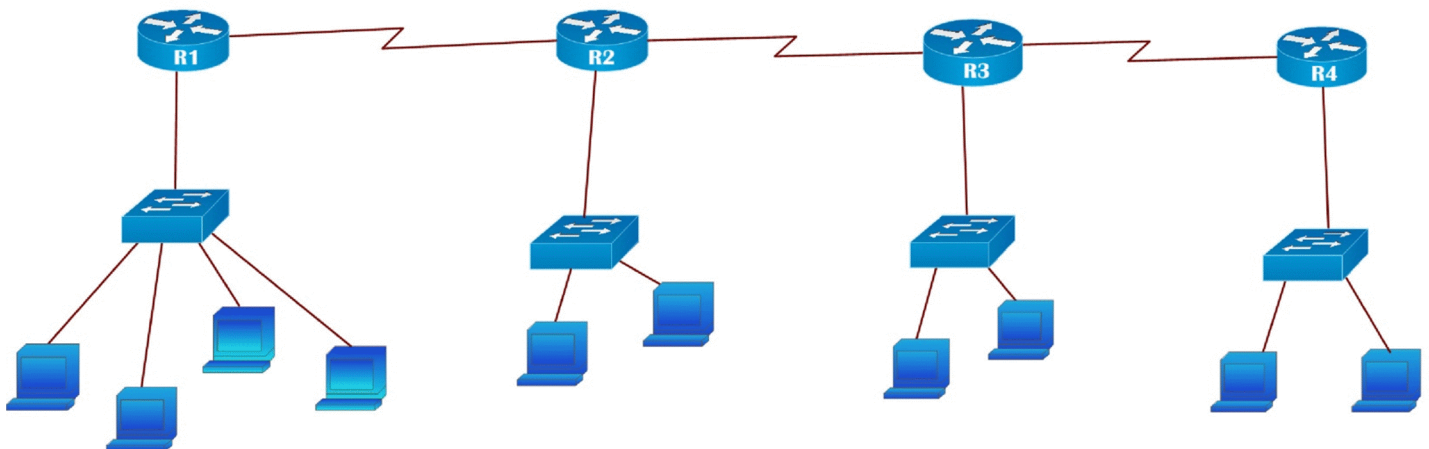


A Back to Back Cable is used which emulates the copper wire, modems and MUX, the complete exchange setup.

V.35 Back to Back Cable



Assigning IP address on Cisco routers

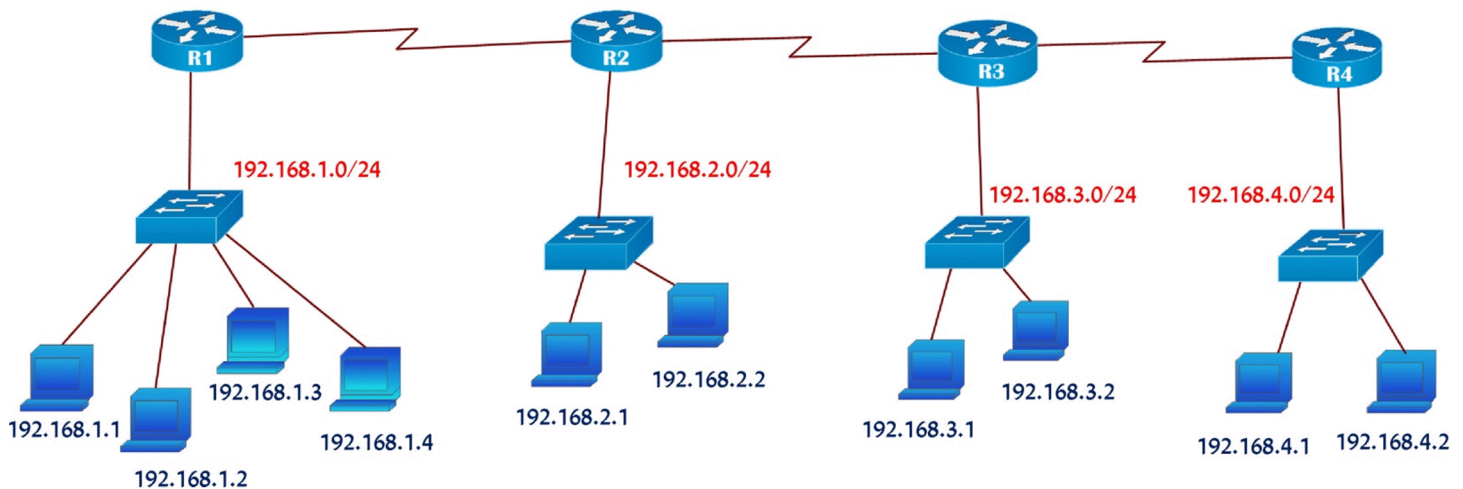


Rules to assign the IP address to the router:

1. All the LAN and WAN should be in different networks (or should not repeat the same networks).
2. Router Ethernet IP and the LAN network assigned should be in the same network.
3. Both the interfaces of router facing each other should be in the same network.
4. All the interfaces of routers should be in the different network.

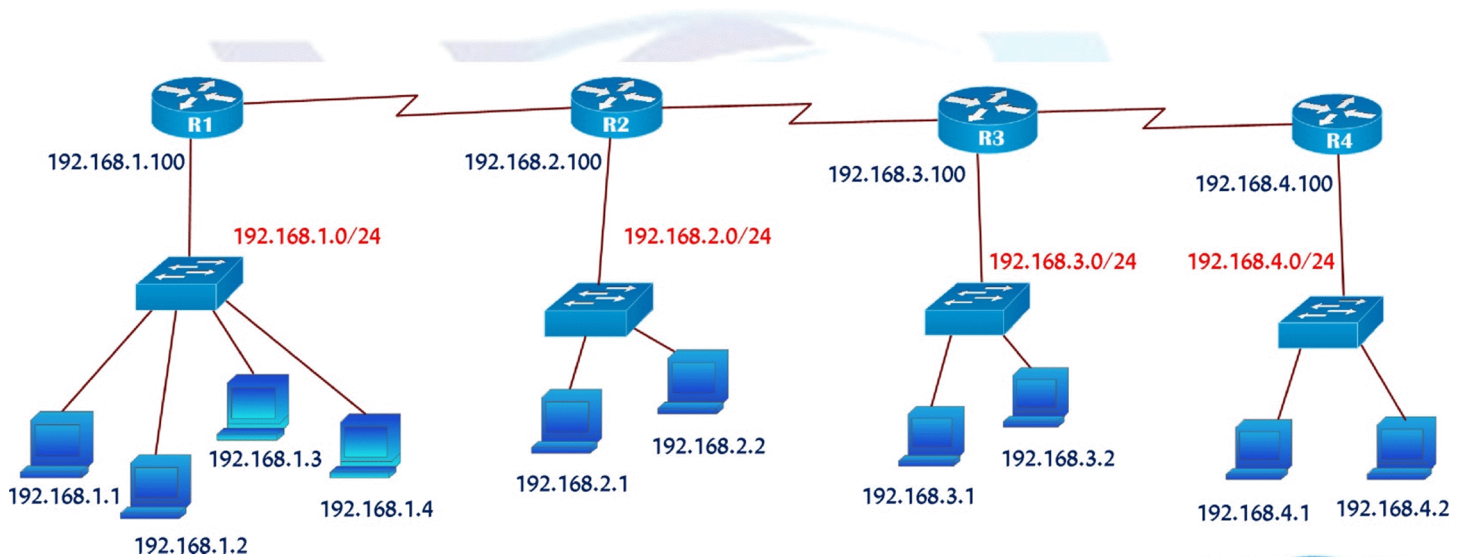
Rules to assign the IP address to the router:

- 1) All the LAN and WAN should be in different networks (or should not repeat the same networks).



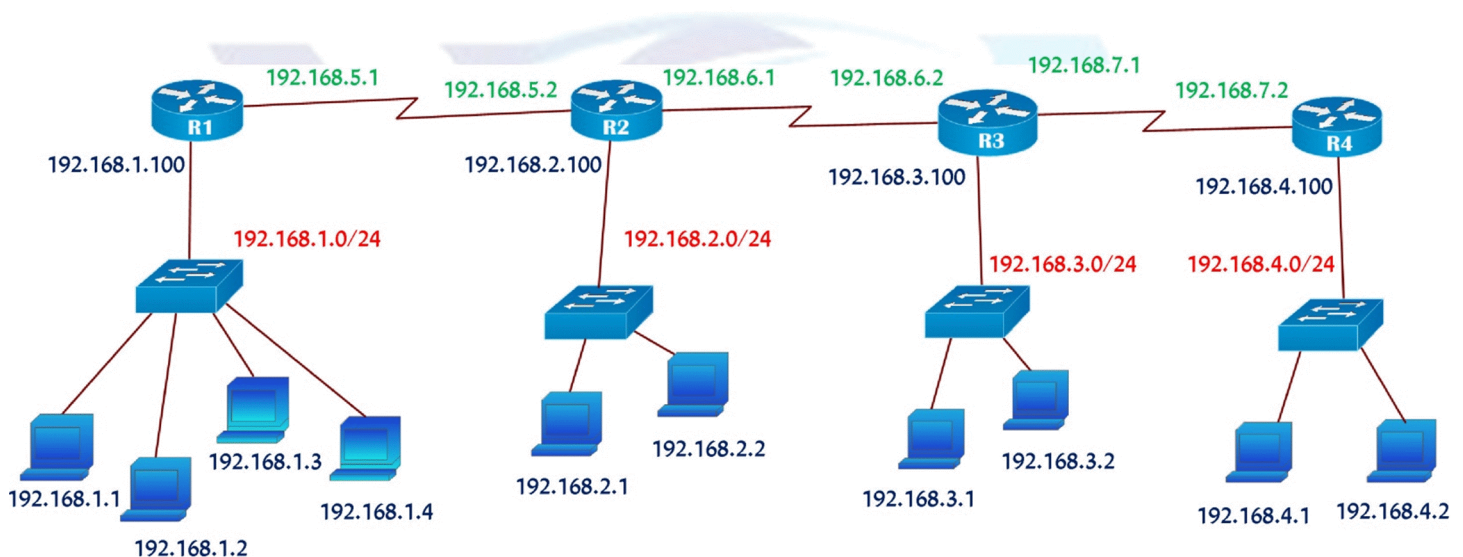
Rules to assign the IP address to the router:

2) Router Ethernet IP and the LAN network assigned should be in the same network.



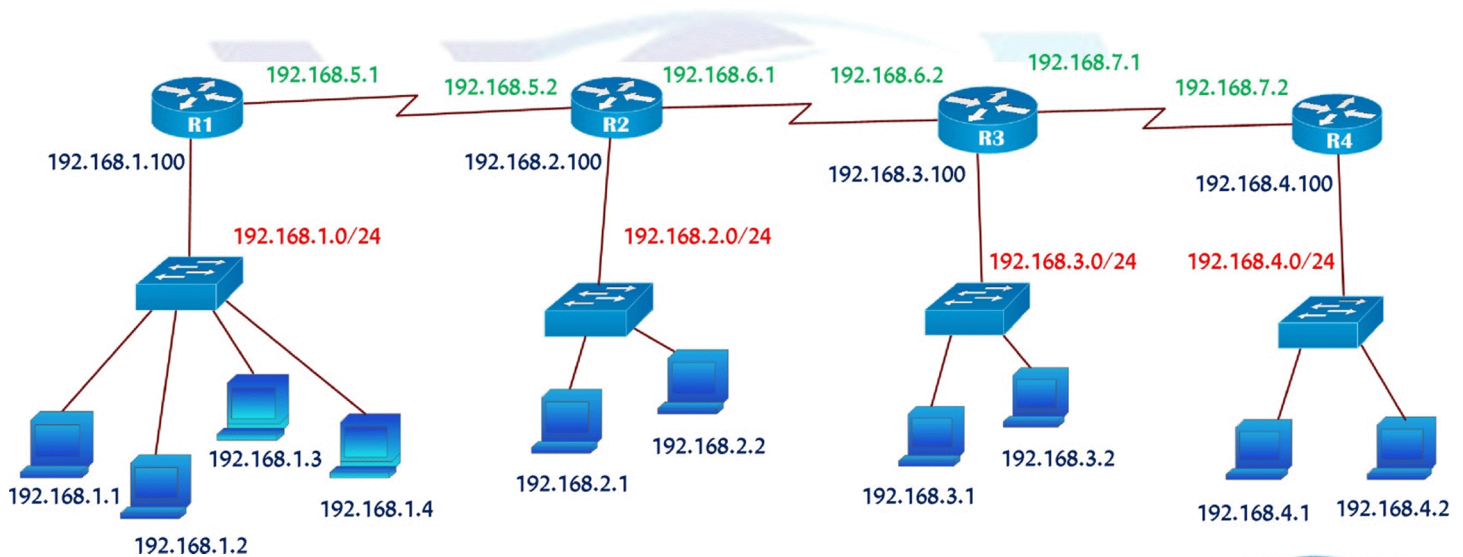
Rules to assign the IP address to the router:

3) Both the interfaces of router facing each other should be in the same network.

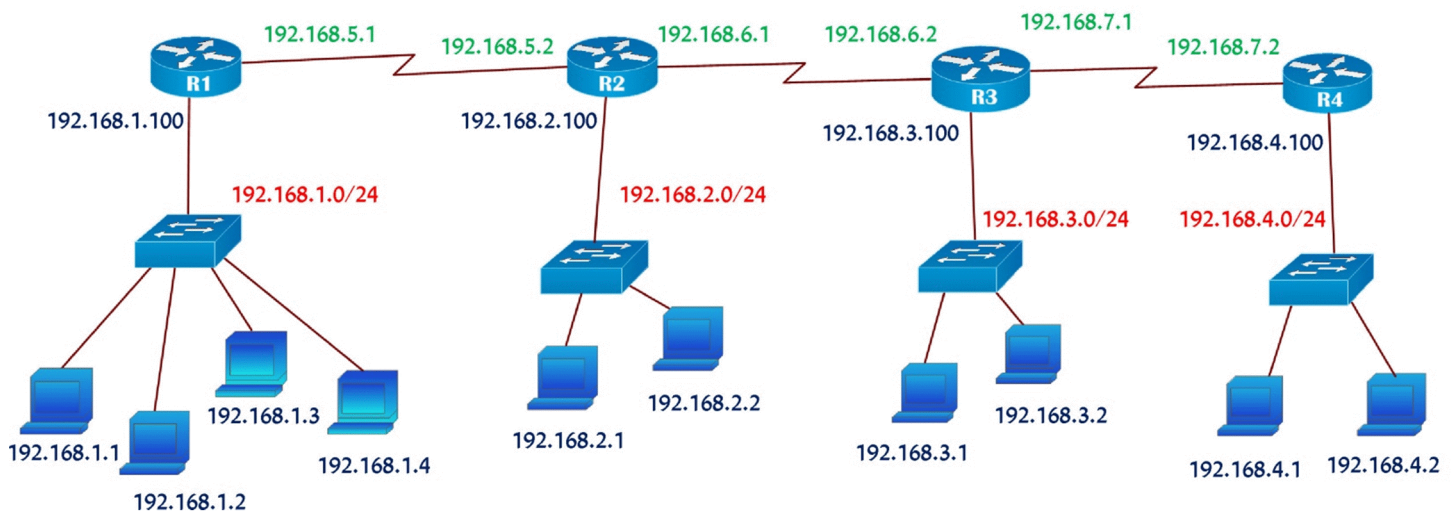


Rules to assign the IP address to the router:

4) All the interfaces of router should be in different networks.



Assigning IP address as per rules

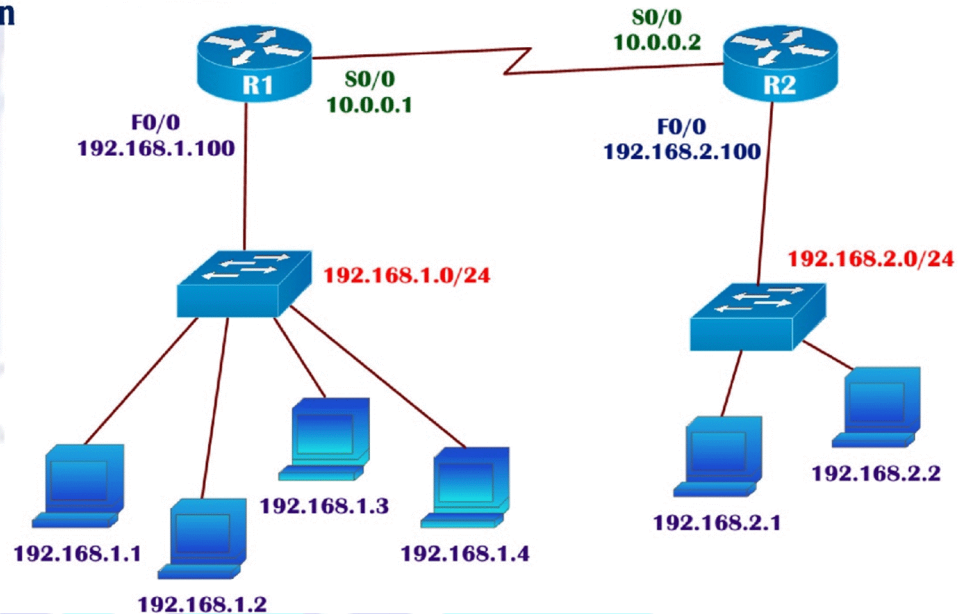


Assigning IP address on Cisco routers

Router(config) # interface <interface type> <interface no>

Router(config-if) # ip address <ip address> <subnet mask>

Router(config-if) # no shutdown



Assigning IP address on Cisco routers

R1(config) # interface fastethernet 0/0

R1(config-if) # ip address 192.168.1.100 255.255.255.0

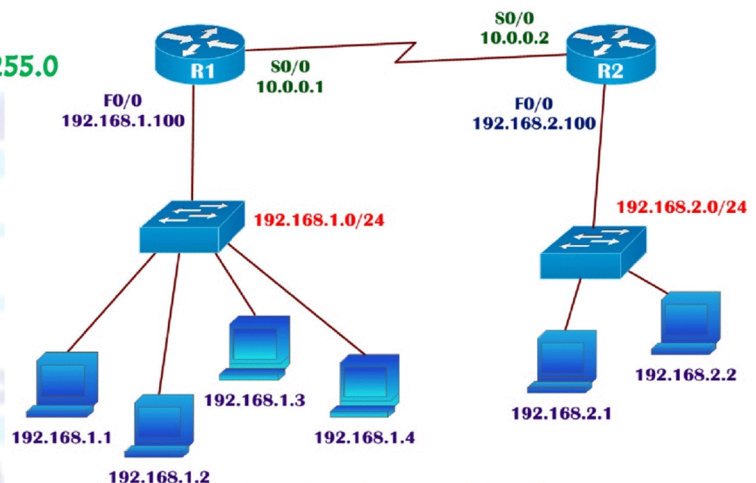
R1(config-if) # no shutdown

R1(config) # interface serial 0/0

R1(config-if) # ip address 10.0.0.1 255.0.0.0

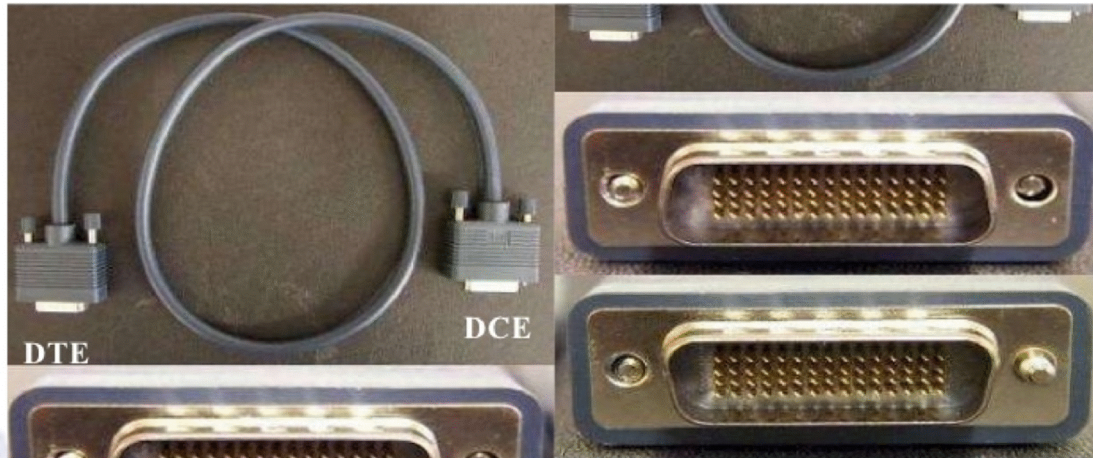
R1(config-if) # no shutdown

R1(config-if) # Clock rate 64000



- Clock rate command only applicable in lab scenarios as we are using back to back v.35 cables
- In real world, we use v.35 modems which generate clocking .

DTE- DCE v.35 cable



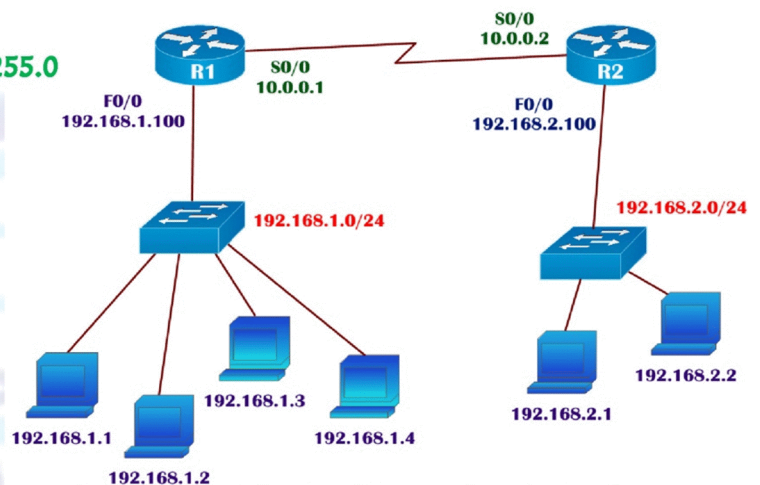
- Back to back cable will be one side DTE and other side DCE
- Clock rate command applies only on interface facing DCE.

R-1#show ip interface brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.1.100	YES	manual	up	up
FastEthernet0/1	unassigned	YES	unset	administratively down	down
Serial0/0	10.0.0.1	YES	manual	up	up
Serial0/1	unassigned	YES	unset	administratively down	down

Assigning IP address on Cisco routers

```
R2(config) # interface fastethernet 0/0
R2(config-if) # ip address 192.168.2.100 255.255.255.0
R2(config-if) # no shutdown
```

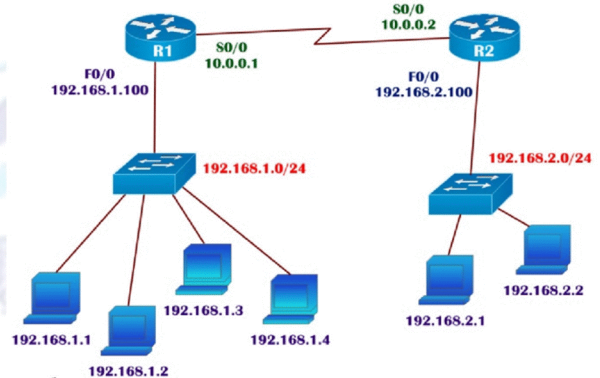


```
R2(config) # interface serial 0/0
R2(config-if) # ip address 10.0.0.2 255.0.0.0
R2(config-if) # no shutdown
R2(config-if) #exit
```

Verify IP address

R-1#show ip interface brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.1.100	YES	manual	up	up
FastEthernet0/1	unassigned	YES	unset	administratively down	down
Serial0/0	10.0.0.1	YES	manual	up	up
Serial0/1	unassigned	YES	unset	administratively down	down



R-1#ping 10.0.0.2

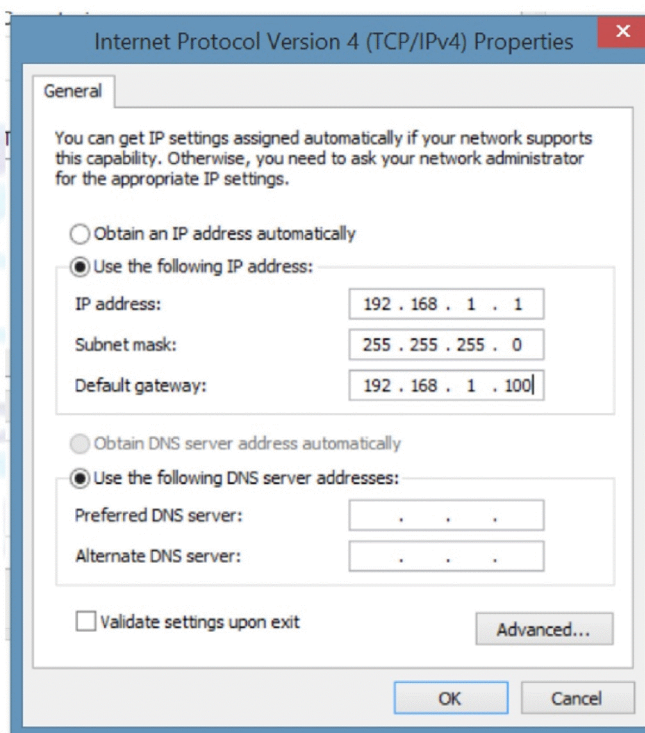
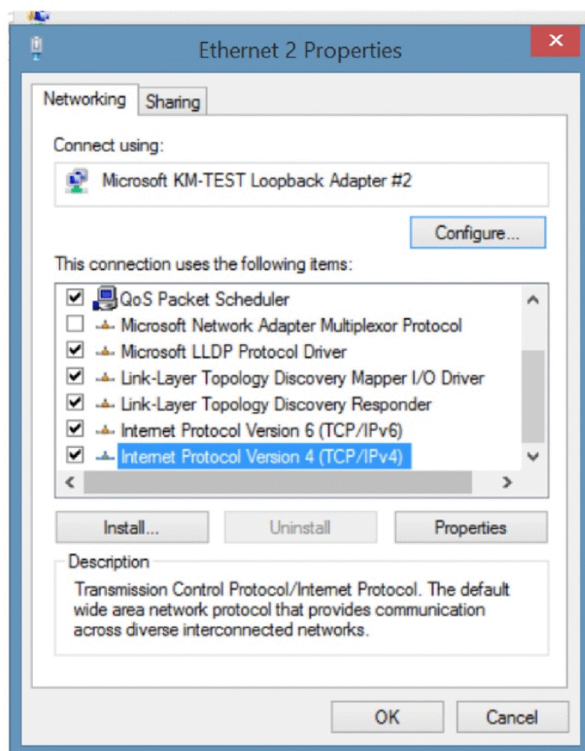
Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.0.0.2, timeout is 2 seconds:

!!!!

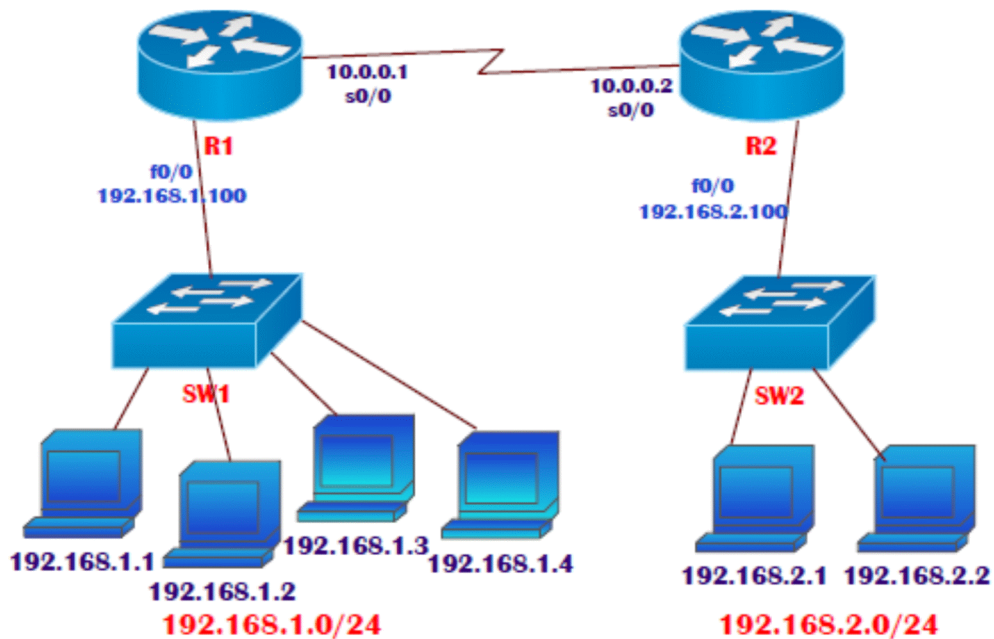
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/8/17 ms

Assigning IPv4 Address to a Hosts in LAN



NOA
NETWORK ONLINE ACADEMY

LAB: BASIC IP CONFIGURATION:



TASK:

1. Design the topology as per the above diagram
2. Configure Ip address as per the diagram and rules
3. Verify the Interface status using command
show ip interface brief

ON ROUTER - 1

```
Router> enable
```

```
Router# configure terminal
```

```
Router (config) # hostname R-1
```

```
R-1(config)# interface fastEthernet 0/0
```

```
R-1(config-if)# ip address 192.168.1.100 255.255.255.0
```

```
R-1(config-if)# no shutdown
```

```
R-1(config-if)#
```

```
%LINK-5-CHANGED: Interface FastEthernet0/0, changed state to up
```

```
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
```

```
R-1(config-if)#exit
```

```
R-1(config)#interface serial 0/0
```

```
R-1(config-if)#ip address 10.0.0.1 255.0.0.0
```

```
R-1(config-if)# no shutdown
```

```
R-1(config-if)# clock rate 64000
```

NOTE:

- clock rate is only required in the lab scenario as we are using a back to back cable instead of the real exchange where the modems will be installed which will generate the clocking
- here clock rate has to be generated manually using clock rate command

R-1#show ip interface brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.1.100	YES	manual	up	up
FastEthernet0/1	unassigned	YES	unset	administratively down	down
Serial0/0	10.0.0.1	YES	manual	down	down
Serial0/1	unassigned	YES	unset	administratively down	down

ON ROUTER -2

Router> enable

Router# configure terminal

Router(config)# hostname R-2

R-2(config)# interface fastEthernet 0/0

R-2(config-if)# ip address 192.168.2.100 255.255.255.0

R-2(config-if)#no shutdown

%LINK-5-CHANGED: Interface FastEthernet0/0, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up

R-2(config-if)#exit

R-2(config)# interface serial 0/0

R-2(config-if)#ip address 10.0.0.2 255.0.0.0

R-2(config-if)#no shutdown

R-2(config-if)# clock rate 64000

%LINK-5-CHANGED: Interface Serial0/0, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/0, changed state to up

R-2#show ip interface brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.2.100	YES	manual	up	up
FastEthernet0/1	unassigned	YES	unset	administratively down	down
Serial0/0	10.0.0.2	YES	manual	up	up
Serial0/1	unassigned	YES	unset	administratively down	down

R-1#show ip interface brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.1.100	YES	manual	up	up
FastEthernet0/1	unassigned	YES	unset	administratively down	down
Serial0/0	10.0.0.1	YES	manual	up	up
Serial0/1	unassigned	YES	unset	administratively down	down

R-2#ping 10.0.0.1

Type escape sequence to abort.

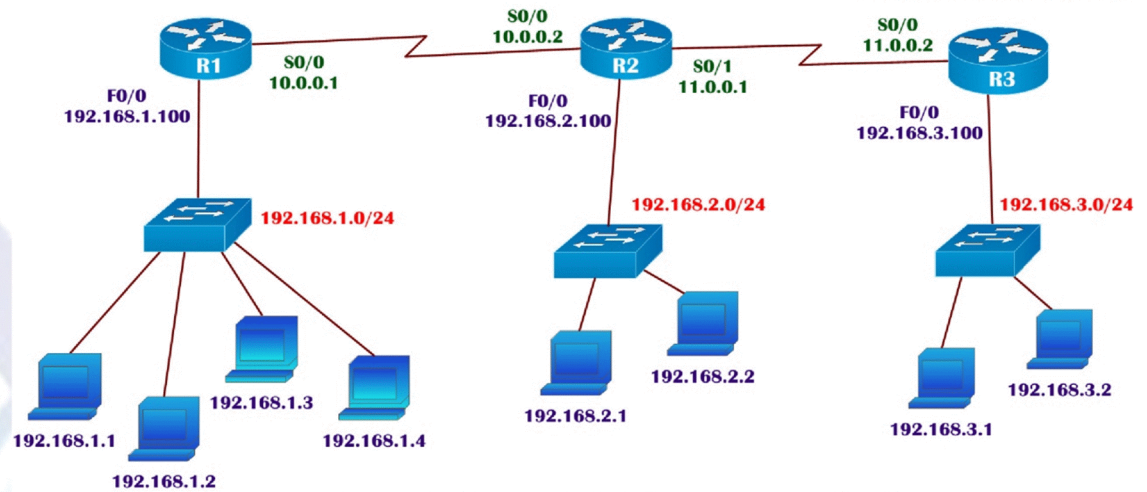
Sending 5, 100-byte ICMP Echos to 10.0.0.1, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 2/4/8 ms



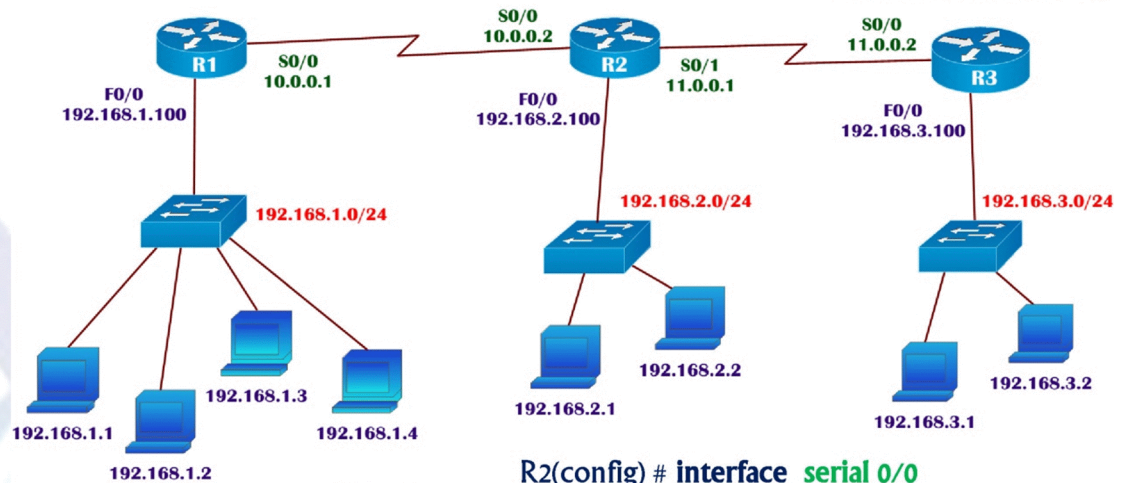
Basic IP address configuration – 3 routers



```
R1(config) # interface fastethernet 0/0
R1(config-if) # ip address 192.168.1.100 255.255.255.0
R1(config-if) # no shutdown
```

```
R1(config) # interface serial 0/0
R1(config-if) # ip address 10.0.0.1 255.0.0.0
R1(config-if) # no shutdown
R1(config-if) # Clock rate 64000
```

Basic IP address configuration – 3 routers

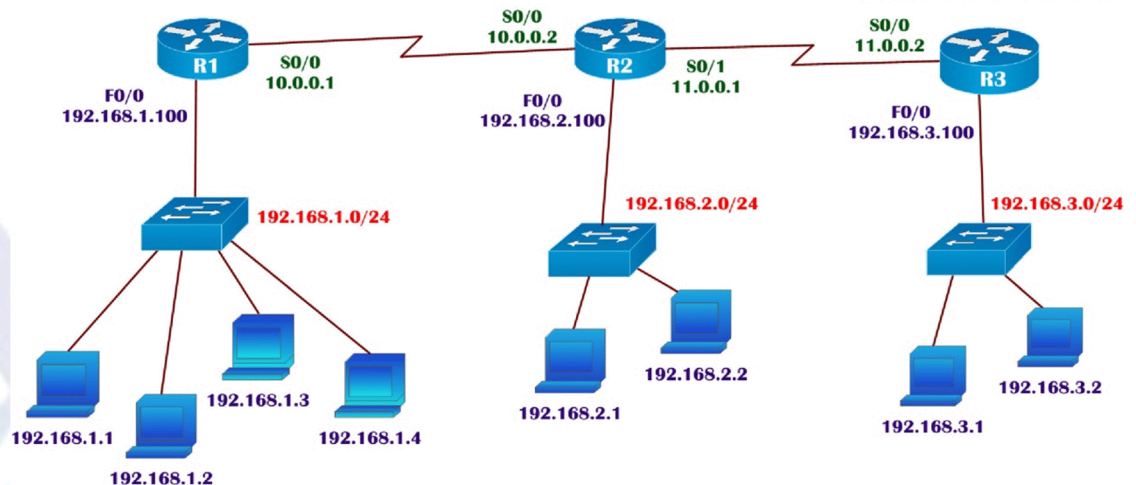


```
R2(config) # interface fastethernet 0/0
R2(config-if) # ip address 192.168.2.100 255.255.255.0
R2(config-if) # no shutdown
```

```
R2(config) # interface serial 0/0
R2(config-if) # ip address 10.0.0.2 255.0.0.0
R2(config-if) # no shutdown
R2(config-if) # exit
```

```
R2(config) # interface serial 0/1
R2(config-if) # ip address 11.0.0.1 255.0.0.0
R2(config-if) # no shutdown
R2(config-if) # clock rate 64000
```

Basic IP address configuration – 3 routers



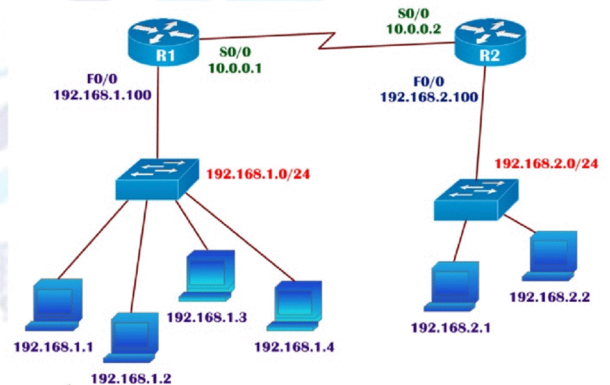
```
R3(config) # interface fastethernet 0/0
R3(config-if) # ip address 192.168.3.100 255.255.255.0
R3(config-if) # no shutdown
```

```
R3(config) # interface serial 0/0
R3(config-if) # ip address 11.0.0.2 255.0.0.0
R3(config-if) # no shutdown
R3(config-if) # exit
```

Verify IP address

R-1#show ip interface brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.1.100	YES	manual	up	up
FastEthernet0/1	unassigned	YES	unset	administratively down	down
Serial0/0	10.0.0.1	YES	manual	up	up
Serial0/1	unassigned	YES	unset	administratively down	down



R-1#ping 10.0.0.2

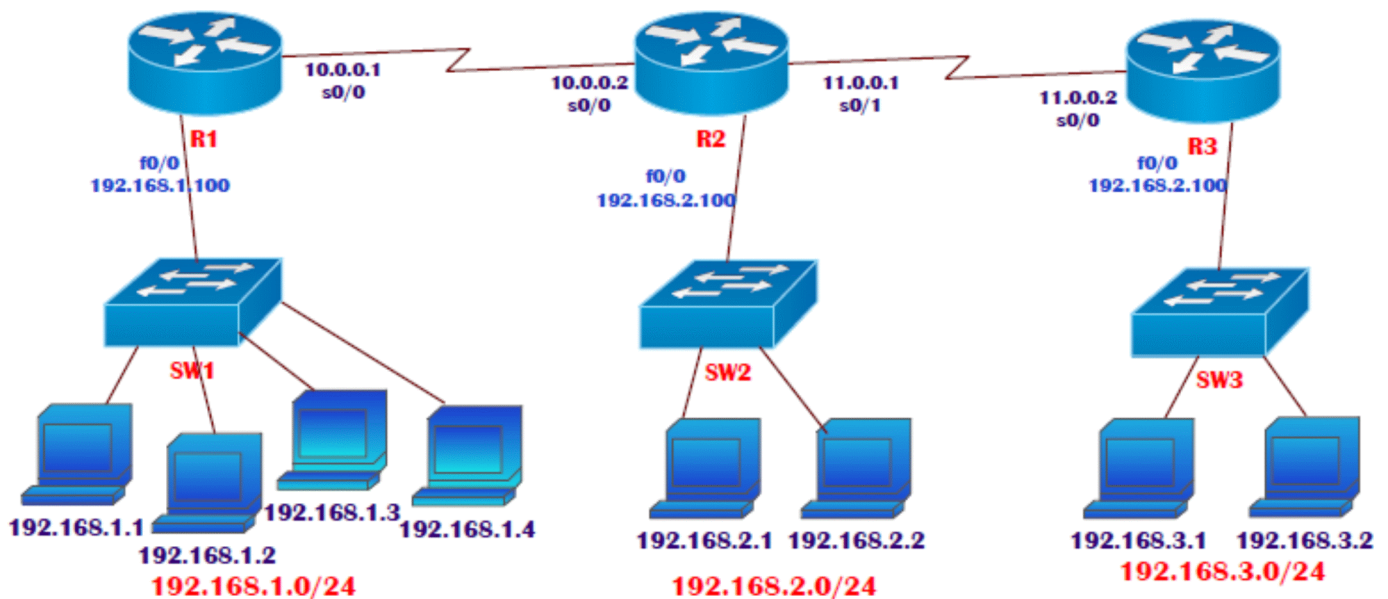
Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.0.0.2, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/8/17 ms

LAB: BASIC CONFIGURATION USING THREE ROUTERS



ROUTER - 1

```
Router(config)# hostname R-1
R-1(config)# interface fastEthernet 0/0
R-1(config-if)# ip address 192.168.1.100 255.255.255.0
R-1(config-if)# no shutdown
%LINK-5-CHANGED: Interface FastEthernet0/0, changed state to up
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
R-1(config-if)#exit
R-1(config)#interface serial 0/0
R-1(config-if)#ip address 10.0.0.1 255.0.0.0
R-1(config-if)#no shutdown
R-1(config-if)# clock rate 64000
```

NOTE:

- clock rate is only required in the lab scenario as we are using a back to back cable instead of the real exchange where the modems will be installed which will generate the clocking
- here clock rate has to be generated manually using clock rate command

R-1#show ip interface brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.1.100	YES	manual	up	up
FastEthernet0/1	unassigned	YES	unset	administratively down	down
Serial0/0	10.0.0.1	YES	manual	down	down
Serial0/1	unassigned	YES	unset	administratively down	down

ROUTER -2

```
R-2>enable
R-2(config)# interface fastEthernet 0/0
R-2(config-if)# ip address 192.168.2.100 255.255.255.0
R-2(config-if)#no shutdown
```

```
%LINK-5-CHANGED: Interface FastEthernet0/0, changed state to up
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
```

```
R-2(config-if)#exit
R-2(config)# interface serial 0/0
R-2(config-if)# ip address 10.0.0.2 255.0.0.0
R-2(config-if)#no shutdown
R-2(config-if)#clock rate 64000
```

```
%LINK-5-CHANGED: Interface Serial0/0, changed state to up
%LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/0, changed state to up
```

```
R-2(config)# interface serial 0/1
R-2(config-if)# ip address 11.0.0.1 255.0.0.0
R-2(config-if)# no shutdown
R-2(config-if)#clock rate 64000
```

```
R-2#show ip interface brief
```

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.2.100	YES	manual	up	up
FastEthernet0/1	unassigned	YES	unset	administratively down	down
Serial0/0	10.0.0.2	YES	manual	up	up
Serial0/1	11.0.0.1	YES	manual	down	down

ROUTER- 3

```
Router>enable
Router#conf t
Router(config)#hostname R-3
R-3(config)#interface fastEthernet 0/0
R-3(config-if)# ip address 192.168.3.100 255.255.255.0
R-3(config-if)#no shutdown
```

```
%LINK-5-CHANGED: Interface FastEthernet0/0, changed state to up
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
```

```
R-3(config-if)#exit
R-3(config)#interface serial 0/0
```

R-3(config-if)#ip address 11.0.0.2 255.0.0.0

R-3(config-if)#no shutdown

R-3(config-if)#clock rate 64000

R-3(config-if)# end

R-3#show ip interface brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.3.100	YES	manual	up	up
FastEthernet0/1	unassigned	YES	unset	administratively down	down
Serial0/0	11.0.0.2	YES	manual	up	up
Serial0/1	unassigned	YES	unset	administratively down	down

R-2#ping 10.0.0.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.0.0.1, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 4/12/44 ms

R-2#ping 11.0.0.2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 11.0.0.2, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 4/7/20 ms

NOTE:

Once the interfaces are up you should be able to ping to the directly connected interfaces of the other routers

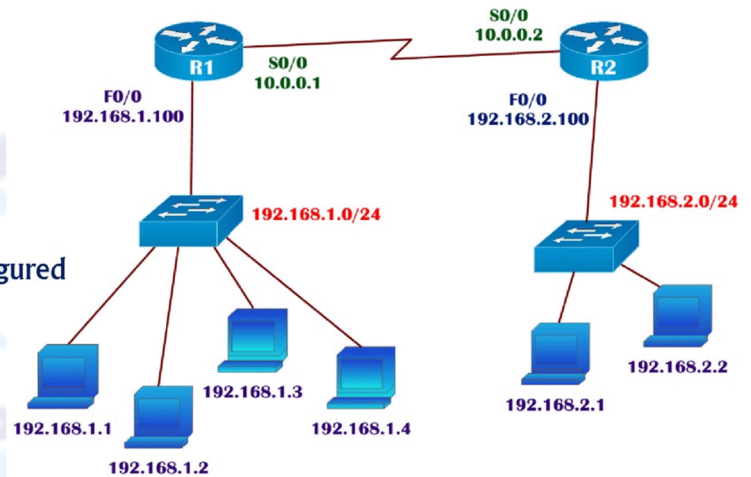
Troubleshooting Connectivity

1) Serial is up, line protocol is up

- Connectivity is fine.

2) Serial is down, line protocol is down

- remote device turned off
- remote port is in shutdown state
 - interface on the remote router has to be configured
- problem with connectivity



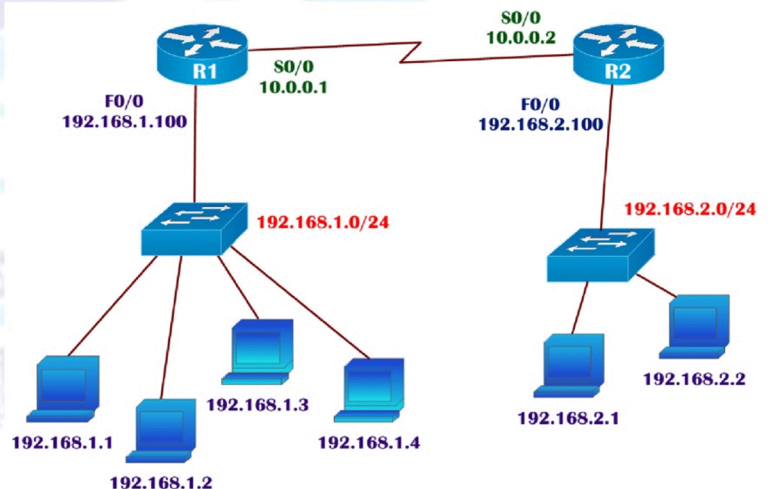
3) Serial is administratively down, line protocol is down

- local port is in shut down state
 - No Shutdown has to be given on the local router interface

Troubleshooting Connectivity

4) Serial is up, line protocol is down

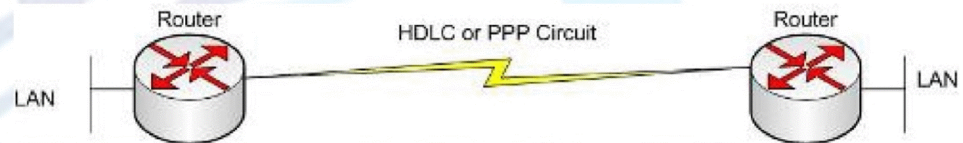
- Encapsulation mismatch
- clock rate command not given on serial interface (only applies in lab scenario)
- if using PPP , then authentication mismatch



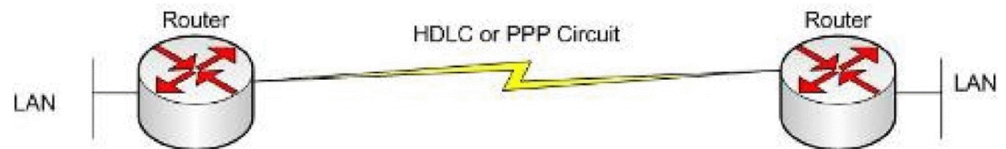
We will come back to this slide after WAN protocols and PPP authentication process

WAN PROTOCOLS

- Defines format of data to be send on the WAN links
- Also referred as encapsulation
- HDLC & PPP



WAN PROTOCOLS



HDLC	PPP
Higher level data link Control protocol	Point to Point Protocol
Default on serial links	Change to PPP
Cisco Proprietary	Standard Protocol
NO support Authentication, Compression & error correction	Supports Authentication, compression & error correction

R-1#show interfaces s0/0

```
Serial0/0 is up, line protocol is up (connected)
Hardware is HD64570
Internet address is 10.0.0.1/8
MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
  reliability 255/255, txload 1/255, rxload 1/255
Encapsulation HDLC, loopback not set, keepalive set (10 sec)
```

```
R-1(config)#interface serial 0/0
R-1(config-if)#encapsulation ppp
R-1(config-if)#end
```

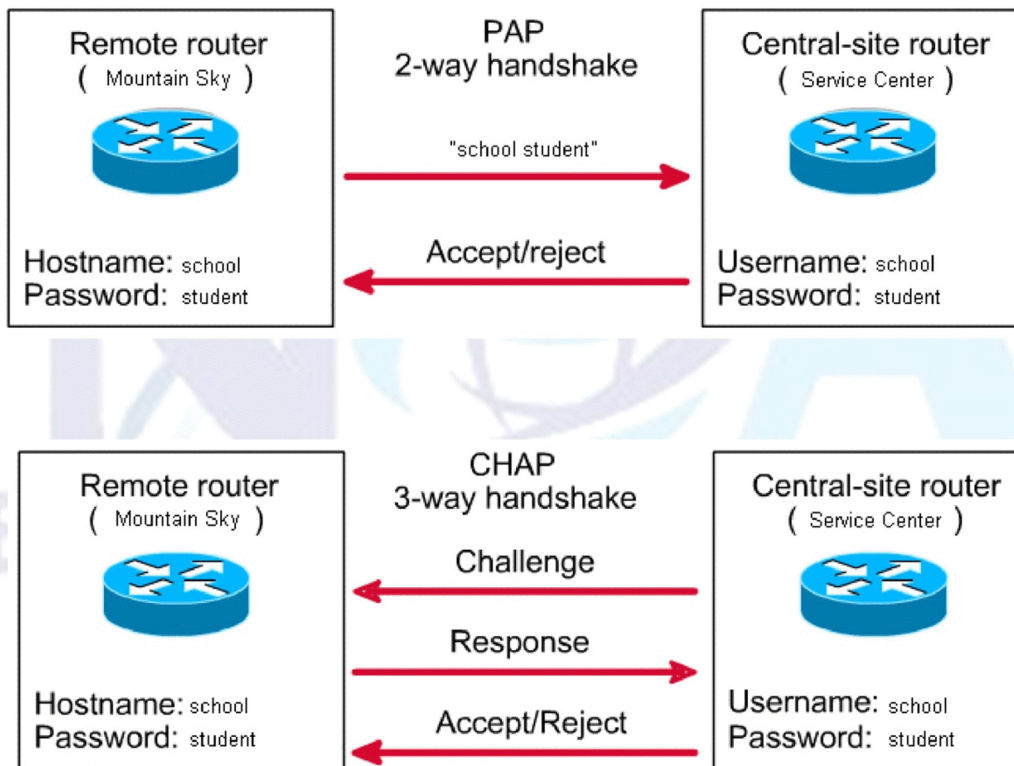
R-1#sh interfaces serial 0/0

```
Serial0/0 is up, line protocol is down (disabled)
Hardware is HD64570
Internet address is 10.0.0.1/8
MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
  reliability 255/255, txload 1/255, rxload 1/255
Encapsulation PPP, loopback not set, keepalive set (10 sec)
```

PPP Authentication

PAP	CHAP
Password Authentication Protocol	Challenge Handshake Authentication Protocol
2 way hand-shake process	3 way hand-shake process
Password is send in clear text	Password is send in encrypted text (MD5)

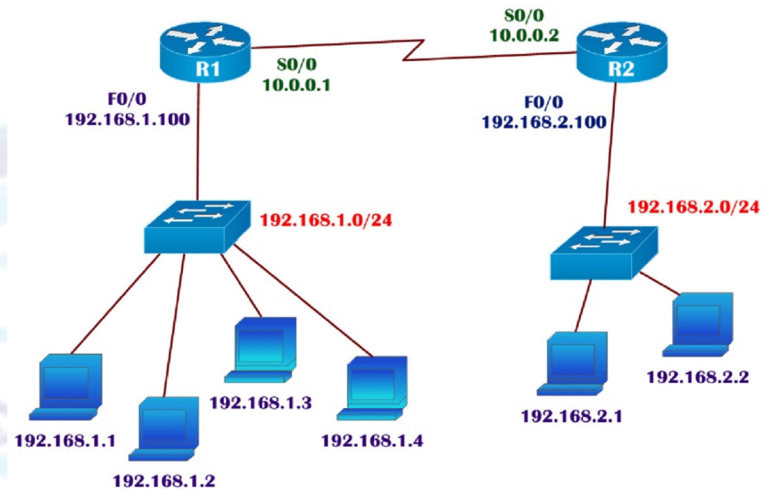
PAP vs. CHAP



CHAP configuration on R1/R2

On both Routers

```
R-x(config)#interface serial 0/0  
R-x(config-if)#encapsulation ppp  
R-x(config-if)#ppp authentication chap  
R-x(config-if)#exit
```



```
R-1(config)#username R-2 password noa123
```

```
R-2(config)#username R-1 password noa123
```

Username must match the remote hostname

PAP Configuration on R1

```
R-1(config)#username R-2 password noa123
```

Username must match the remote hostname

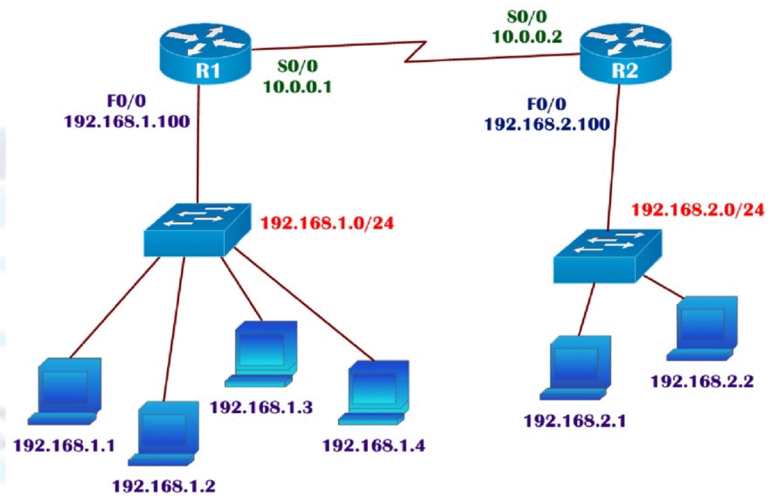
```
R-1(config)#interface serial 0/0
```

```
R-1(config-if)#encapsulation ppp
```

```
R-1(config-if)#ppp authentication pap
```

```
R-1(config-if)#ppp pap sent-username R-1 password noa123
```

```
R-1(config-if)#exit
```



Username under interface must match the local hostname

PAP Configuration on R2

```
R-2(config)#username R-1 password noa123
```

Username must match the remote hostname

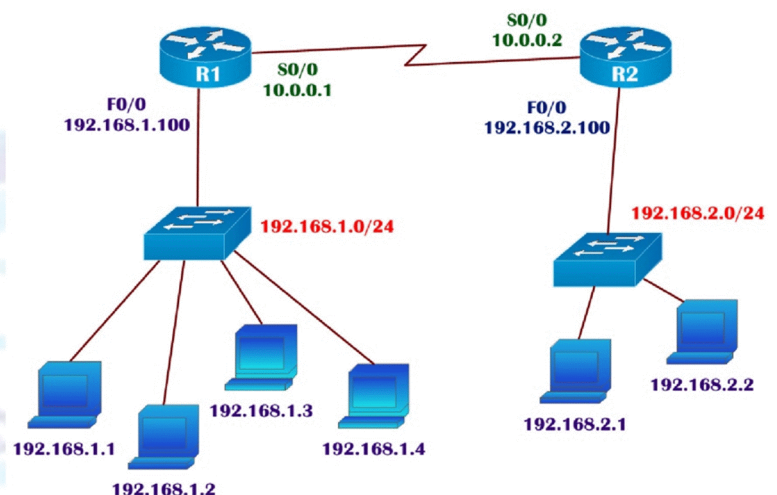
```
R-2(config)#interface serial 0/0
```

```
R-2(config-if)#encapsulation ppp
```

```
R-2(config-if)#ppp authentication pap
```

```
R-2(config-if)#ppp pap sent-username R-2 password noa123
```

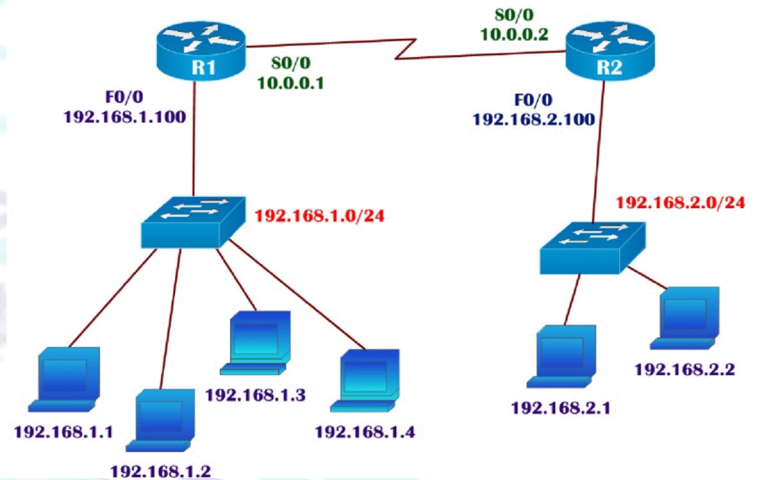
```
R-2(config-if)#exit
```



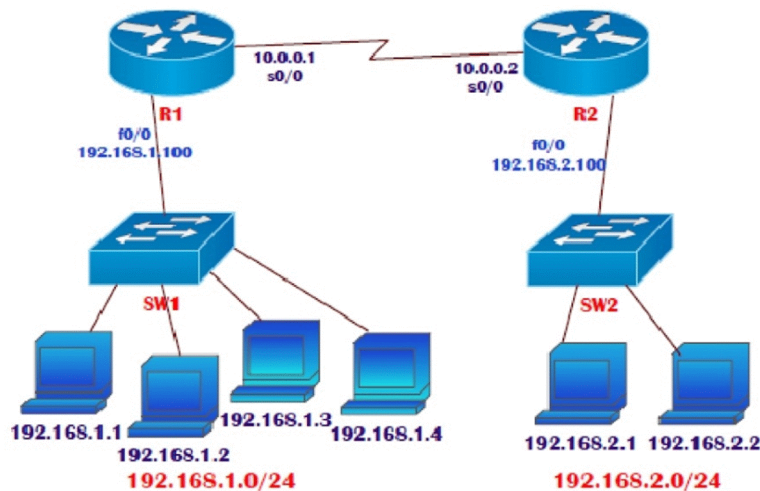
Username under interface must match the local hostname

4) Serial is up, line protocol is down

- Encapsulation mismatch (PPP/HDLC)
- clock rate command not given on serial interface (only applies in lab scenario)
- if using PPP , then authentication mismatch (protocol/ username/password)



LAB: PPP Authentication using CHAP



TASK:

- Continue with the same previous lab connecting R1/R2 where IP address is pre-configured.
- configure R1/R2 to use PPP authentication using PAP

R-1#sh ip int brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.1.100	YES	manual	up	up
FastEthernet0/1	unassigned	YES	unset	administratively down	down
Serial0/0	10.0.0.1	YES	manual	up	up
Serial0/1	unassigned	YES	unset	administratively down	down

R-1#sh int s0/0

Serial0/0 is up, line protocol is up (connected)
Hardware is HD64570
Internet address is 10.0.0.1/8
MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
reliability 255/255, txload 1/255, rxload 1/255
Encapsulation HDLC, loopback not set, keepalive set (10 sec)

TASK: Configure PPP Authentication using CHAP on both R1/R2

R1/R2

```
R-x(config)#int s0/0
R-x(config-if)# encapsulation ppp
R-x(config-if)# ppp authentication chap
R-x(config-if)# exit
```

```
R-1(config)#username R-2 password cisco123
```

```
R-2(config)#username R-1 password cisco123
```

```
R-2#sh ip int brief
```

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.2.100	YES	manual	up	up
FastEthernet0/1	unassigned	YES	unset	administratively down	down
Serial0/0	10.0.0.2	YES	manual	up	up
Serial0/1	unassigned	YES	unset	administratively down	down

R-2#ping 10.0.0.1

Type escape sequence to abort.

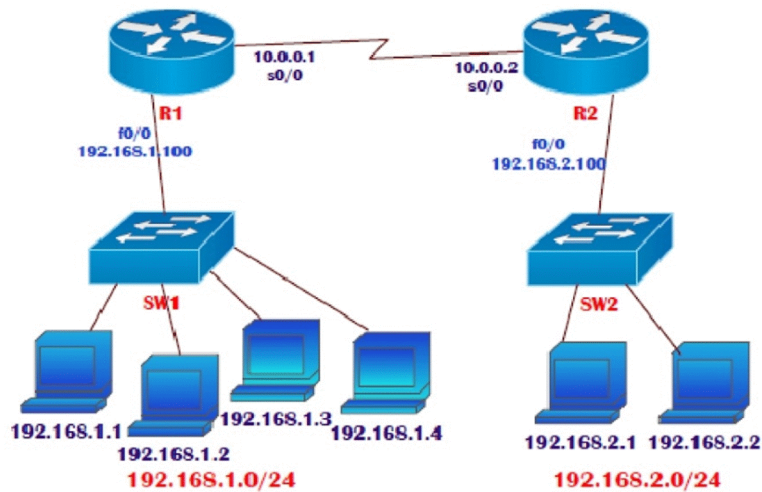
Sending 5, 100-byte ICMP Echos to 10.0.0.1, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/5/14 ms



LAB: PPP Authentication using PAP



TASK:

- Continue with the same previous lab connecting R1/R2 where IP address is pre-configured.
- Remove the encapsulation PPP and reconfigure PPP Authentication using PAP.

```
R-1(config)#username R-2 password cisco123
```

```
R-1(config)#int s0/0
```

```
R-1(config-if)#no encapsulation ppp
```

```
R-1(config-if)#encapsulation ppp
```

```
R-1(config-if)#ppp authentication pap
```

```
R-1(config-if)#ppp pap sent-username R-1 password cisco123
```

```
R-1(config-if)#end
```

```
R-2#sh ip int brief
```

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.2.100	YES	manual	up	up
FastEthernet0/1	unassigned	YES	unset	administratively down	down
Serial0/0	10.0.0.2	YES	manual	up	down
Serial0/1	unassigned	YES	unset	administratively down	down

```
R-2(config)#username R-1 password cisco123
```

```
R-2(config)#int s0/0
```

```
R-2(config-if)#encapsulation ppp
```

```
R-2(config-if)#ppp authentication pap
```

```
R-2(config-if)#ppp pap sent-username R-2 password cisco123
```

```
R-2(config-if)#end
```


R-2#sh ip int brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.2.100	YES	manual	up	up
FastEthernet0/1	unassigned	YES	unset	administratively down	down
Serial0/0	10.0.0.2	YES	manual	up	up
Serial0/1	unassigned	YES	unset	administratively down	down

R-2#ping 10.0.0.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.0.0.1, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 2/3/7 ms

Test your Skills:

- What is CSU/DSU?
- What is the difference between DTE and DCE?
- Define the rules to assign the IP address to the router:
- What is the syntax for assigning IP address on Cisco routers?
- Differentiate PPP & HDLC?
- Differentiate PAP & CHAP?
- What is the syntax for PAP & CHAP Authentication?
- What are the outputs we get using # show ip interface brief command and explain the possible issues to check while troubleshooting connectivity?

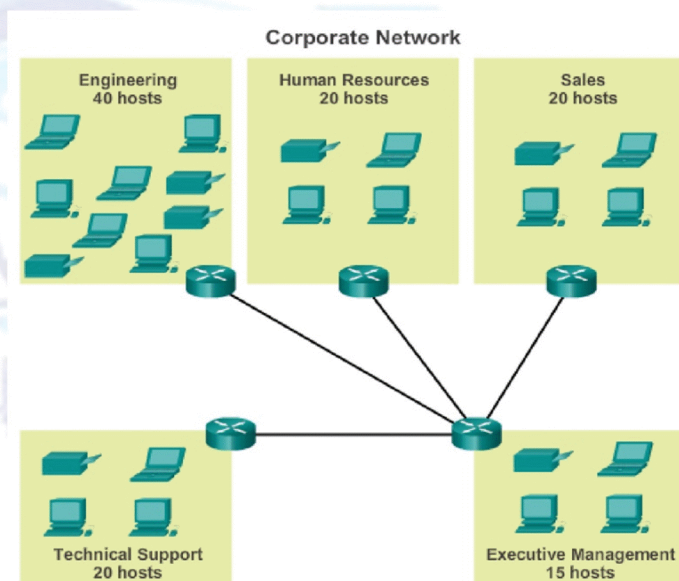
Subnetting

FLSM, VLSM, Subnetting Questions

Subnetting



- ▶ is the process of Dividing a Single Network into Multiple smaller networks.
- ▶ helps in minimizing the wastage of IP address.



FLSM & VLSM

Subnetting can be performing in two ways.

- **FLSM** (Fixed Length Subnet Mask)
- **VLSM** (Variable Length subnet mask)

Subnetting can be done based on requirement.

- Requirement of Hosts? $2^h - 2 \geq \text{requirement}$
- Requirement of Networks? $2^n \geq \text{requirement}$

H = host bits , N = Network Bits

What we do in Subnetting

- Converting Host bits into Network Bits (reducing number of host bits)
 - i.e. Converting 0's into 1's

2 Power Table

2^1	2
2^2	4
2^3	8
2^4	16
2^5	32
2^6	64
2^7	128

2^8	256
2^9	512
2^{10}	1024
2^{11}	2048
2^{12}	4096
2^{13}	8192
2^{14}	16384

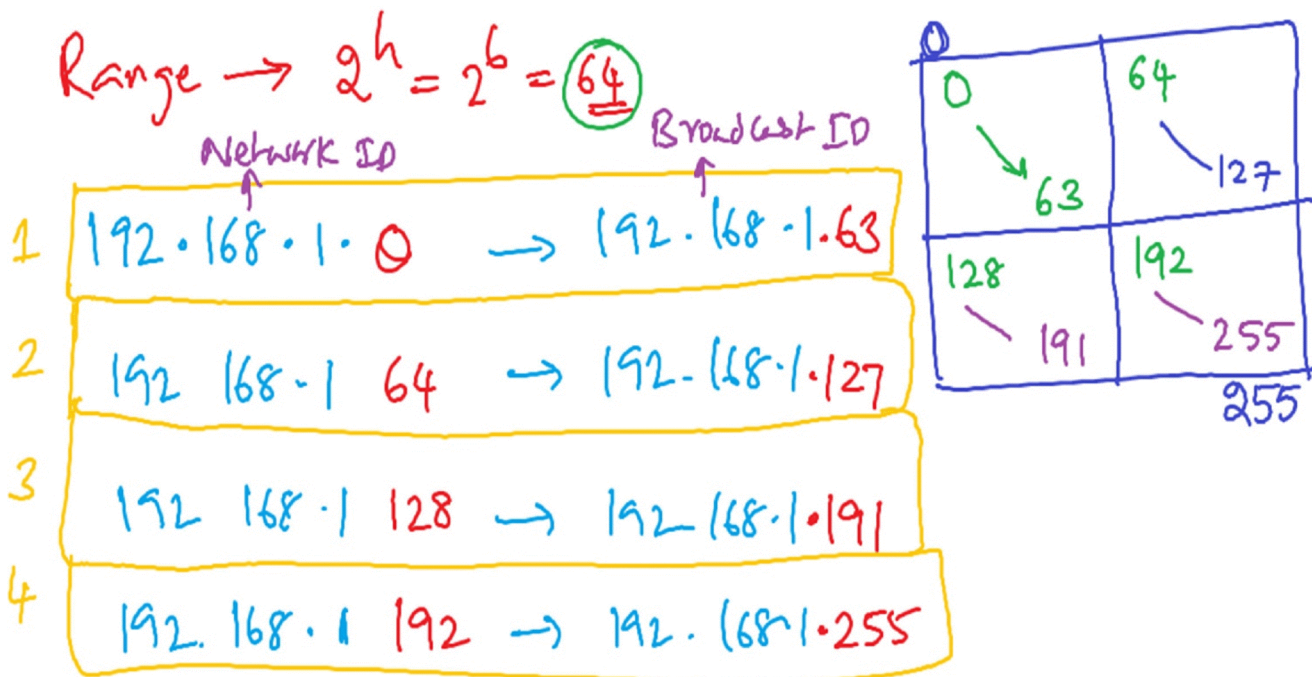
Value in Subnet mask

VALUES IN SUBNET MASK		
Bit	Value	Mask
1	128	10000000
2	192	11000000
3	224	11100000
4	240	11110000
5	248	11111000
6	252	11111100
7	254	11111110
8	255	11111111

C-CLASS, Req = 50 hosts (FLSM) N. N. N. H 24/8 26/6

$2^4 - 2 \geq \text{Req}$
 $2^6 - 2 \geq 50$ Net-ID
B-ID
 $64 - 2$
62 Valid hosts

$\text{mask} = \leftarrow 255.255.255.192$ 2
 Required H. Bits = 6
 Converted N. Bits = $\text{Total H. Bits} - \text{Req. H. Bits}$
 $8 - 6 = 2$
 total N. Bits = $24 + 2 = 26$



FLSM: Example—1

Req = 40 hosts using C-class address network 192.168.1.0/24

$$2^h - 2 \geq \text{req}$$

$$2^6 - 2 \geq 40$$

$$64 - 2 \geq 40$$

$$62 \geq 40$$

- Host bits required (h) = 6
- Converted network Bits (n) = Total. H. Bits -- req. H. Bits

$$= 8 - 6 = 2$$
- Converted network Bits (n) = 2
- Total . N. Bits = default N bits + converted N bits = $24 + 2 = /26$
- Hosts/Subet = $2^h - 2 = 2^6 - 2 = 64 - 2$

$$= 62 \text{ Hosts/Subet}$$
- Subnets = $2^n = 2^2 = 4 \text{ Subnets}$
- Customized subnet mask = (/26) = 255.255.255.192

Range: $2^h = 2^6 = 64$

Network ID	---	Broadcast ID
• 192.168.1.0/26	-----	192.168.1.63/26
• 192.168.1.64/26	-----	192.168.1.127/26
• 192.168.1.128/26	-----	192.168.1.191/26
• 192.168.1.192/26	-----	192.168.1.255/26



REQ = 30 Hosts, C-class

$$2^h - 2 \geq \text{req}$$

$$2^5 - 2 \geq 30$$

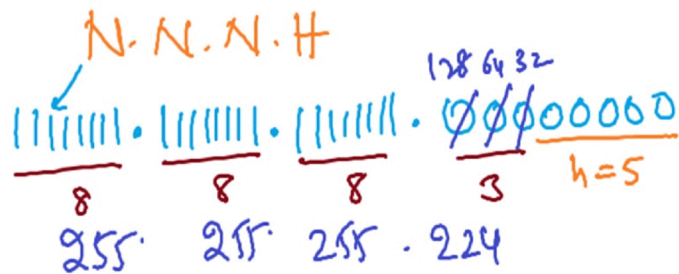
$$32 - 2$$

30 - valid hosts.

$$h = 5 \checkmark$$

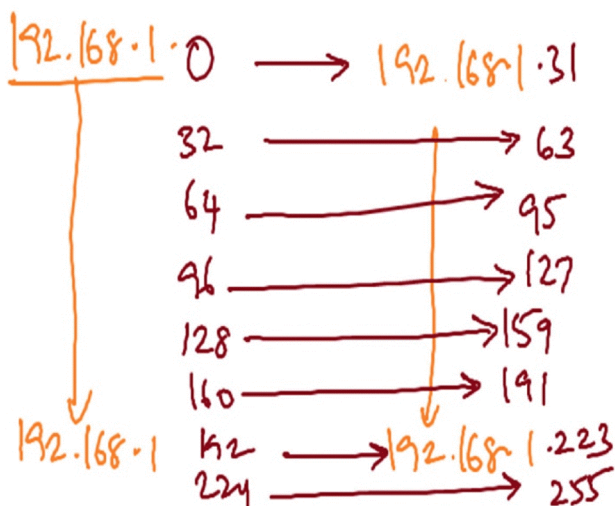
$$\text{Can. Bits } (n) = 8 - 5 = 3$$

$$\text{Total. Nbrs} = 24 + 3 = 27$$



$$\text{Subnets} = 2^h = 2^3 = 8 \text{ subnets}$$

$$\text{Range} - 2^h = 2^5 = 32$$



0 → 31	32 → 63	64 → 95	96 → 127
128 → 159	160 → 191	192 → 223	224 → 255

FLSM: Example—2

Req = 30 hosts using C-class address network 192.168.1.0/24

$$2^h - 2 \geq \text{req}$$

$$2^5 - 2 \geq 30$$

$$32 - 2 \geq 30$$

$$30 \geq 30$$

- Host bits required (h) = 5
- Converted network Bits (n) = Total. H. Bits -- req. H. Bits
$$= 8 - 5 = 3$$
- Converted network Bits (n) = 3
- Total . N. Bits = default N bits + converted N bits = $24 + 3 = /27$
- Hosts/Subet = $2^h - 2 = 2^5 - 2 = 32 - 2$
$$= 30 \text{ Hosts/Subet}$$
- Subnets = $2^n = 2^3 = 8 \text{ Subnets}$
- Customized subnet mask = (/27) = 255.255.255.224

Range: $2^h = 2^5 = 32$

Network ID	---	Broadcast ID
• 192.168.1.0/27	----	192.168.1.31/27
• 192.168.1.32/27	----	192.168.1.63/27
• 192.168.1.64/27	----	192.168.1.95/27
• 192.168.1.96/27	----	192.168.1.127/27
• 192.168.1.128/27	----	192.168.1.159/27
• 192.168.1.160/27	----	192.168.1.191/27
• 192.168.1.192/27	----	192.168.1.223/27
• 192.168.1.224/27	----	192.168.1.255/27

UNDERSTANDING SUBNETS

$\left. \begin{array}{l} 92.168.1.10 \\ 92.168.1.100 \end{array} \right\}$

Same net $255.255.255.0 \rightarrow (h=8)$
 $2^h = 2^8 = 256$
 $(0 - 255)$

$255.255.255.192$
 $\frac{8}{8} \quad \frac{8}{8} \quad \frac{8}{8} \quad \frac{2}{2} \quad | \quad h=6$
 different
 $2^h = 2^6 = 64$

0-63
 64-127
 128-191
 192-255

Req $\Rightarrow$ 1000 hosts, using B-class:- (0-65535)

$$2^h - 2 \geq \text{req}$$

$$2^{10} - 2 \geq 1000$$

$$1024 - 2$$

1022 — valid hosts.

$$h=10$$

$$\text{Can. N. Bits} = 16 - 10 = 6$$

$$\text{totl. N. bits} = 16 + 6 = 22$$

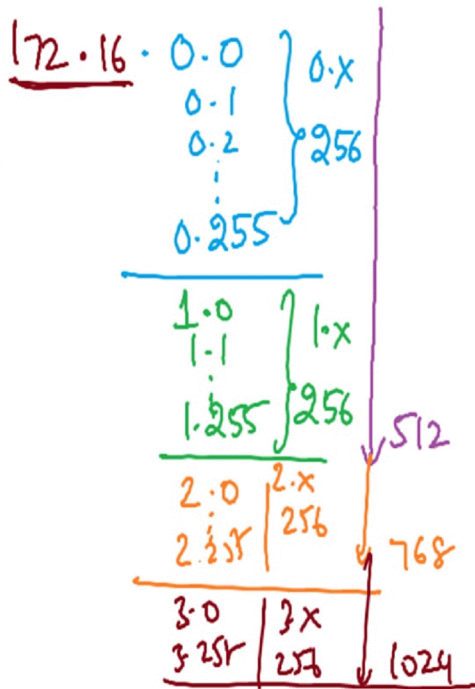
$$N \cdot N \cdot H \cdot H$$

$$\frac{11111111 \cdot 11111111 \cdot 00000000 \cdot 00000000}{8 \cdot 8 \cdot 6 \cdot 0} \quad h=10$$

$$\text{Mask } 255.255.252.0$$

Cancelled N. Bits

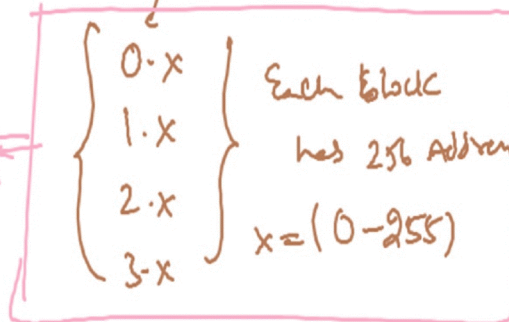
$$\text{Subnets} = 2^h = 2^6 = 64 \text{ Subnets}$$



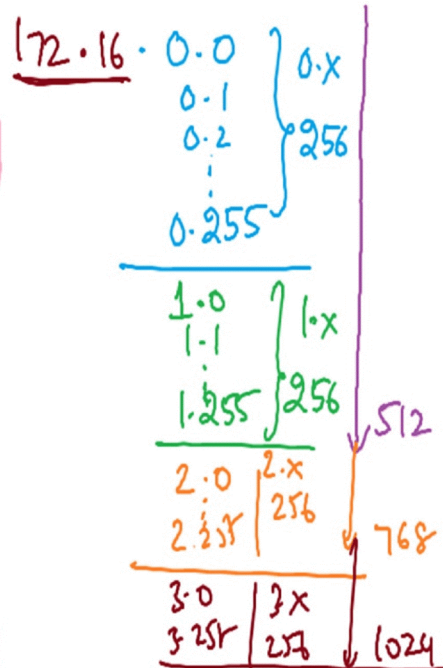
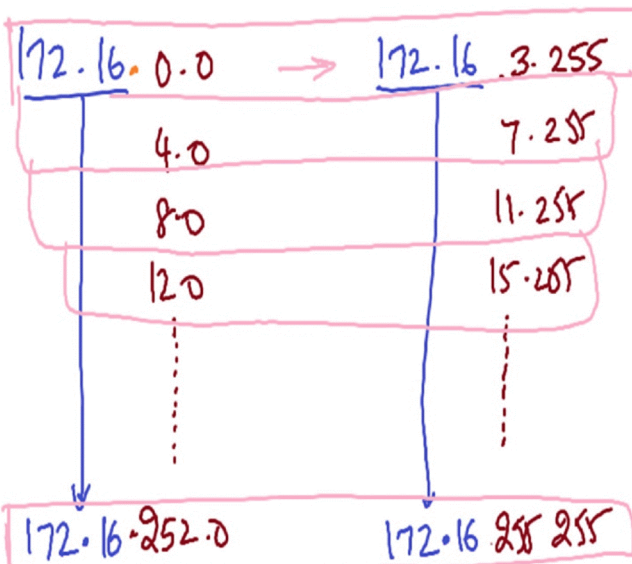
$$2^4 / 256 = 16 / 256$$

4 Blocks

Set of
1024
Addresses



Range - $2^4 = 2^{10} = 1024$



2⁴

Set of
1024
Addresses

FLSM: Example—3

Req = 500 hosts using B-class address network 172.16.0.0/16

$$2^h - 2 \geq \text{req}$$

$$2^9 - 2 \geq 500$$

$$512 - 2 \geq 500$$

$$510 \geq 500$$

Host bits required (h) = 9

$$\begin{aligned}\text{Converted network Bits (n)} &= \text{Total. H. Bits} - \text{req. H. Bits} \\ &= 16 - 9 = 7\end{aligned}$$

Converted network Bits (n) = 7

$$\text{Total. N. Bits} = \text{default N bits} + \text{converted N bits} = 16 + 7 = /23$$

$$\begin{aligned}\text{Hosts/Subet} &= 2^h - 2 = 2^9 - 2 = 512 - 2 \\ &= 510 \text{ Hosts/Subet}\end{aligned}$$

$$\text{Subnets} = 2^n = 2^7 = 128 \text{ Subnets}$$

$$\text{Customized subnet mask} = (/23) = 255.255.254.0$$

$$\text{Range: } 2^h = 2^9 = 512$$

Network ID	---	Broadcast ID
• 172.16.0.0/23	----	172.16.1.255/23
• 172.16.2.0/23	----	172.16.3.255/23
• 172.16.4.0/23	----	172.16.5.255/23
• 172.16.6.0/23	----	172.16.7.255/23
...		
...		
....		
• 172.16.254.0/23	----	172.16.255.255/23

FLSM: Example—4

Req = 4000 hosts using B-class address network 172.16.0.0/16

$$2^h - 2 \geq \text{req}$$

$$2^{12} - 2 \geq 4000$$

$$4096 - 2 \geq 4000$$

$$4094 \geq 4000$$

Host bits required (h) = 12

$$\begin{aligned} \text{Converted network Bits (n)} &= \text{Total. H. Bits} - \text{req. H. Bits} \\ &= 16 - 12 = 4 \end{aligned}$$

Converted network Bits (n) = 4

$$\text{Total. N. Bits} = \text{default N bits} + \text{converted N bits} = 16 + 4 = /20$$

$$\begin{aligned} \text{Hosts/Subnet} &= 2^h - 2 = 2^{12} - 2 = 4096 - 2 \\ &= 4094 \text{ Hosts/Subnet} \end{aligned}$$

$$\text{Subnets} = 2^n = 2^4 = 16 \text{ Subnets}$$

$$\text{Customized subnet mask} = (/20) = 255.255.240.0$$

$$\text{Range: } 2^h = 2^{12} = 4096$$

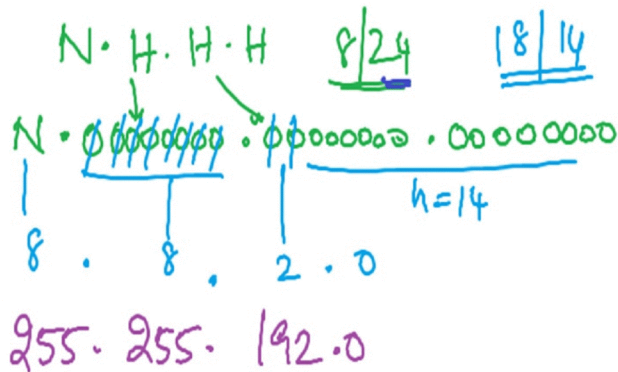
Network ID	---	Broadcast ID
• 172.16.0.0/20	----	172.16.15.255/20
• 172.16.16.0/20	----	172.16.31.255/20
• 172.16.32.0/20	----	172.16.47.255/20
• 172.16.48.0/20	----	172.16.63.255/20
• 172.16.64.0/20	----	172.16.79.255/20
...		
....		
• 172.16.240.0/20	----	172.16.255.255/20

A-class : Req $\Rightarrow$ 16,000 hosts

$$2^h - 2 \geq \text{Req}$$

$$2^{14} - 2 \geq 16,000$$

$$16384 - 2 \Rightarrow \textcircled{16382} \text{ valid hosts}$$



h=14

Available N.bits = $24 - 14 = \textcircled{10}$

Total N.bits = $8 + 10 = 18$

Subnets = $2^n = 2^{10} = 1024$ subnets

Range - $2^h = 2^{14} = \underline{\underline{16384}}$

10.0.0.0 $\rightarrow$ 10.0.63.255

64.0 127.255

128.0 191.255

192.0 255.255

$2^h / 256$

$\frac{16384}{256}$

$\textcircled{64}$

Subnets $\rightarrow$

10.1.0.0

64.0

128.0

192.0

10.2.

10.255.0.0 $\rightarrow$ 10.255.63.255

64.0 127.255

128.0 191.255

192.0 $\rightarrow$ 10.255.255.255

FLSM: Example—5

Req = 2000 hosts using A-class address network 10.0.0.0/8

$$2^h - 2 \geq \text{req}$$

$$2^{11} - 2 \geq 2000$$

$$2048 - 2 \geq 2000$$

$$2046 \geq 2000$$

- Host bits required (h) = 11
- Converted network Bits (n) = Total. H. Bits -- req. H. Bits
= 24 --- 11 = 13
- Converted network Bits (n) = 13
- Total. N. Bits = default N bits + converted N bits = 8 + 13 = /21
- Hosts/Subnet = $2^h - 2 = 2^{11} - 2 = 2048 - 2$
= 2046 Hosts/Subnet
- Subnets = $2^n = 2^{13} = 8192$ Subnets
- Customized subnet mask = (/21) = 255.255.248.0

Range:

Network ID	---	Broadcast ID
• 10.0.0.0/21	...	10.0.7.255/21
• 10.0.8.0/21	...	10.0.15.255/21
• 10.0.16.0/21	...	10.0.23.255/21
...	...	...
• 10.0.248.0/21	...	10.0.255.255/21
• 10.1.0.0/21	---	10.1.7.255/21
• 10.1.8.0/21	---	10.1.15.255/21
• 10.1.16.0/21	---	10.1.23.255/21
....	...	...
• 10.1.248.0/21	...	10.1.255.255/21
• 10.2.0.0/21	---	10.2.7.255/21
• 10.2.8.0/21	---	10.2.15.255/21
• 10.2.16.0/21	---	10.2.23.255/21

- 10.2.248.0/21 ... 10.2.255.255/21
- 10.255.0.0/21 --- 10.0.7.255/21
- 10.255.8.0/21 --- 10.0.15.255/21
- 10.255.16.0/21 -.....- 10.0.23.255/21
- 10.255.248.0/21 10.255.255.255/21

FLSM: Example—6

Req = 32000 hosts using A-class address network 10.0.0.0/8

$$2^h - 2 \geq \text{req}$$

$$2^{15} - 2 \geq 32000$$

$$32768 - 2 \geq 32000$$

$$32766 \geq 32000$$

- Host bits required (h) = 15
- Converted network Bits (n) = Total. H. Bits -- req. H. Bits
= 24 --- 15 = 9
- Converted network Bits (n) = 9
- Total. N. Bits = default N bits + converted N bits = 8 + 9 = /17
- Hosts/Subnet = $2^h - 2 = 2^{15} - 2 = 32768 - 2$
= 32766 Hosts/Subnet
- Subnets = $2^n = 2^9 = 512$ Subnets
- Customized subnet mask = (/17) = 255.255.128.0

$$\text{Range: } 2^h = 32768$$

- | Network ID | --- | Broadcast ID |
|---------------|-----|-----------------|
| • 10.0.0.0/17 | ... | 10.0.127.255/17 |

- | | | |
|-----------------|-----|-----------------|
| • 10.0.128.0/17 | ... | 10.0.255.255/17 |
| • 10.1.0.0/17 | ... | 10.1.127.255/17 |
| • 10.1.128.0/17 | ... | 10.1.255.255/17 |
| • 10.2.0.0/17 | ... | 10.2.127.255/17 |
| • 10.2.128.0/17 | ... | 10.2.255.255/17 |
| • 10.3.0.0/17 | ... | 10.3.127.255/17 |
| • 10.3.128.0/17 | ... | 10.3.255.255/17 |
| • 10.4.0.0/17 | ... | 10.4.127.255/17 |
| • 10.4.128.0/17 | ... | 10.4.255.255/17 |
| • 10.5.0.0/17 | ... | 10.5.127.255/17 |
| • 10.5.128.0/17 | ... | 10.5.255.255/17 |

.....

...

...

...

...

...

- | | | |
|-------------------|-----|-------------------|
| • 10.255.0.0/17 | ... | 10.255.127.255/17 |
| • 10.255.128.0/17 | ... | 10.255.255.255/17 |

FLSM exercises

C- Class

- Requirement 50 hosts
- Requirement 100 hosts
- Requirement 30 hosts

B- Class

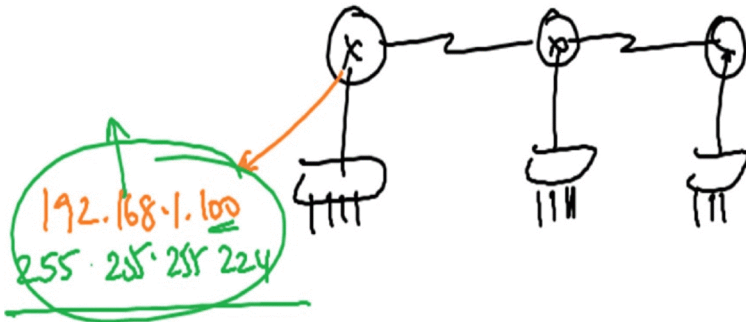
- Requirement 1,000 hosts
- Requirement 4,000 hosts
- Requirement 500 hosts

A-class

- Requirement 16,000 hosts
- Requirement 32,000 hosts



Value :- Represent total N.Bits
- Other way of writing Subnet mask information.



192.168.1.100/27

8 . 8 . 8 . 3
255 255 255 . 224

Value in Subnet mask

VALUES IN SUBNET MASK		
Bit	Value	Mask
1	128	10000000
2	192	11000000
3	224	11100000
4	240	11110000
5	248	11111000
6	252	11111100
7	254	11111110
8	255	11111111

/20:
 /22: → 8 . 8 . 6 . 0
 255 255 252 0
 /25:
 /27: → 8 . 8 . 8 . 3
 255 255 255 224
 /28:
 /30: 8 8 8 6
 255 255 255 252

/15
 /17
 /18
 /21
 /12

/value

bits

Subnet mask

/25

8.8.8.1

255.255.255.128

/28

8.8.8.4

255.255.255.240

/29

8.8.8.5

255.255.255.248

/30

8.8.8.6

255.255.255.252

/23

8.8.7.0

255.255.254.0

/22

8.8.6.0

255.255.252.0

/20

8.8.4.0

255.255.240.0

/18

8.8.2.0

255.255.192.0

/19

8.8.3.0

255.255.224.0

/17

8.8.1.0

255.255.128.0

/15

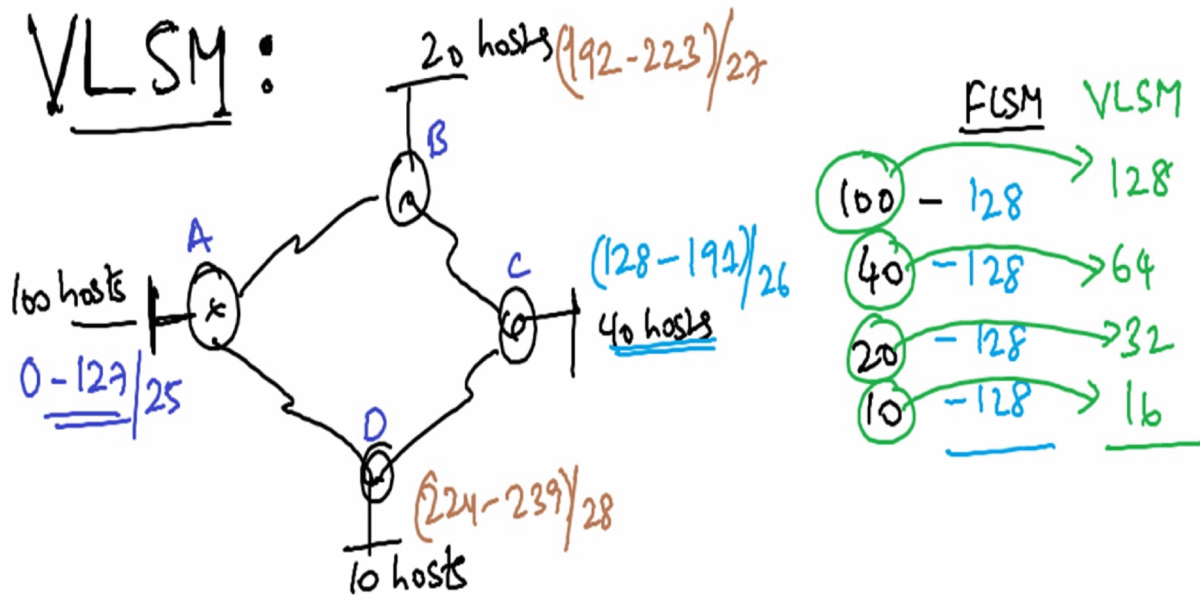
8.7.0.0

255.254.0.0

<u>/Value</u>	<u>Bits</u>	<u>Subnet mask</u>
/20	8.8.4.0	255.255.240.0
/18	8.8.2.0	255.255.192.0
/23	8.8.7.0	255.255.254.0
/25	8.8.8.1	255.255.255.128
/19	8.8.3.0	255.255.224.0
/28	8.8.8.4	255.255.255.240
/29	8.8.8.5	255.255.255.248
/30	8.8.8.6	255.255.255.252
/22	8.8.6.0	255.255.252.0

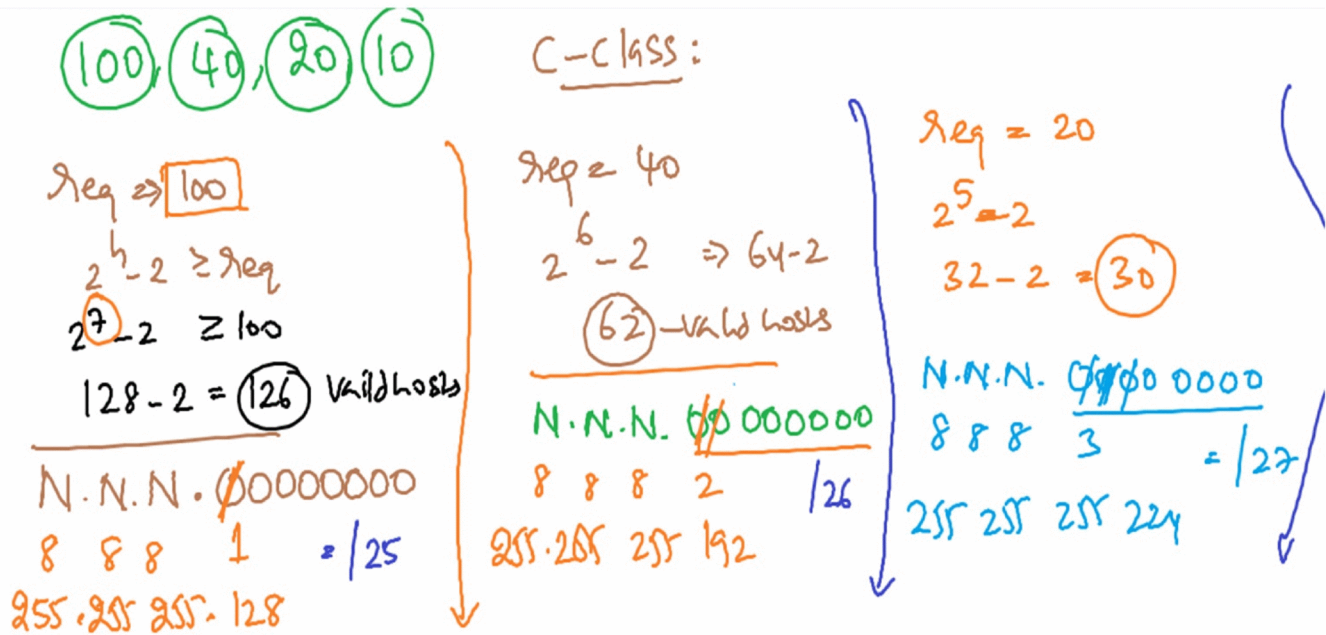


VLSM



VLSM- C-class

Req - 100,40,20,10



$2^5 = 20$
 $2^5 = 2$
 $32 - 2 = 30$

$N.N.N. \text{ } \cancel{0} \cancel{0} \cancel{0} \cancel{0} \cancel{0}$
 $8 \ 8 \ 8 \ 3 = /27$
 $255 \ 255 \ 255 \ 224$

$2^4 = 16$
 $2^4 = 16 - 2 = 14$

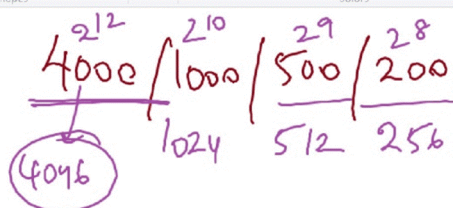
$N.N.N. \cancel{0} \cancel{0} \cancel{0} \cancel{0} \cancel{0}$
 $8 \ 8 \ 8 \ 4 = /28$
 $255 \ 255 \ 255 \ 240$

$$\begin{aligned}
 2^7 = 128 & \leftarrow 192.168.1 \ 0 / 25 \rightarrow 192.168.1.127 / 25 \\
 2^6 = 64 & \quad 192.168.1 \ 128 / 26 \Rightarrow 192.168.1.191 / 26 \\
 2^5 = 32 & \quad 192.168.1 \ 192 / 27 \Rightarrow 192.168.1.223 / 27 \\
 2^4 = 16 & \quad 192.168.1 \ 224 / 28 \Rightarrow 192.168.1.239 / 28
 \end{aligned}$$

VLSM – B-class

Req – 4000, 1000, 500, 200

16. B-class



$$32 - 12 = /20$$

$$32 - 10 = /22$$

$$32 - 9 = /23$$

$$\frac{2^4}{256} \Rightarrow \frac{16 \text{ blocks}}{256} =$$

$$1000 \Rightarrow 4 \text{ blocks}$$

$$512 \rightarrow 2 \text{ blocks}$$

$$256 \rightarrow 1 \text{ block}$$

$$128.16.0.0/20 \Rightarrow 128.16.15.255/20$$

$$128.16.16.0/22 \Rightarrow 128.16.19.255/22$$

$$128.16.20.0/23 \Rightarrow 128.16.21.255/23$$

$$128.16.22.0/24 \Rightarrow 128.16.22.255/24$$

VLSM Exercises

C- class

- Req 100, 50 , 20 , 10
- Req 120, 40 , 12, 4

B-Class

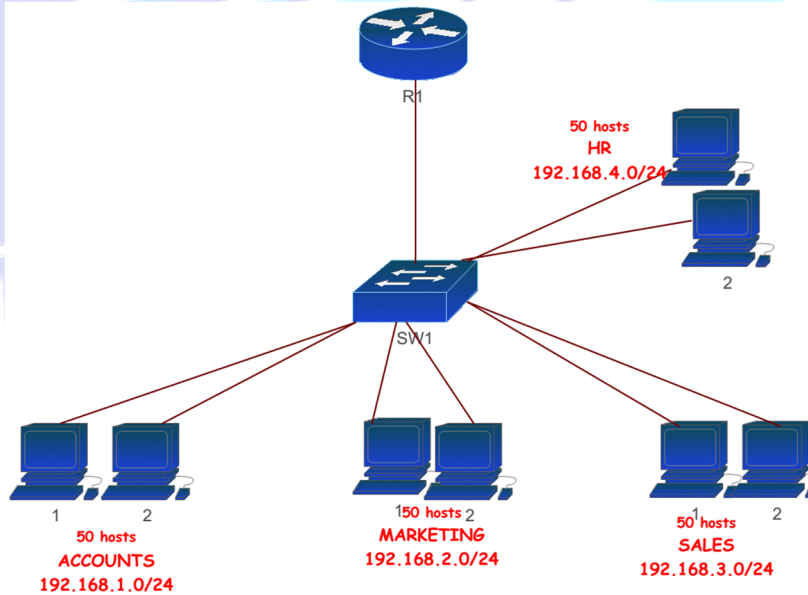
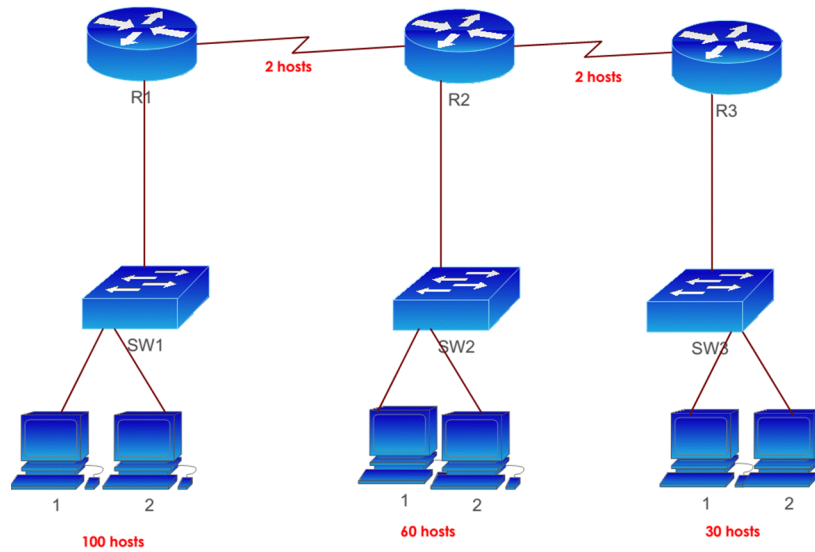
- Req 4000, 1000 , 500, 200
- Req 16000, 2000 , 200, 120, 100

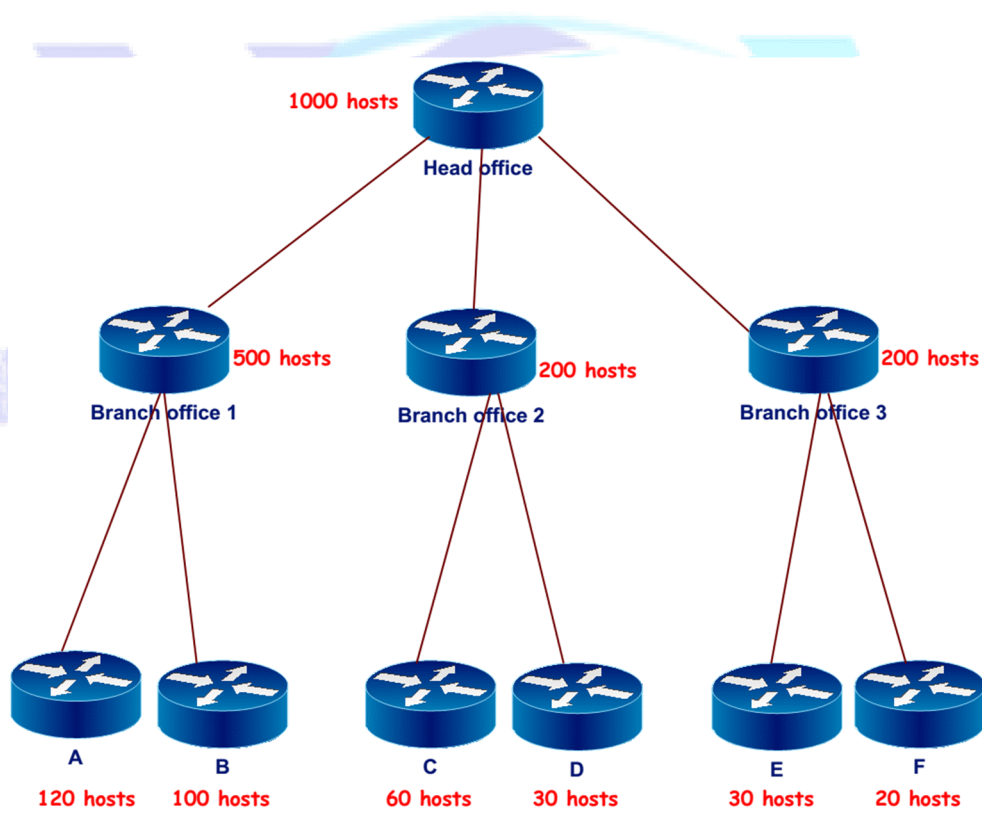
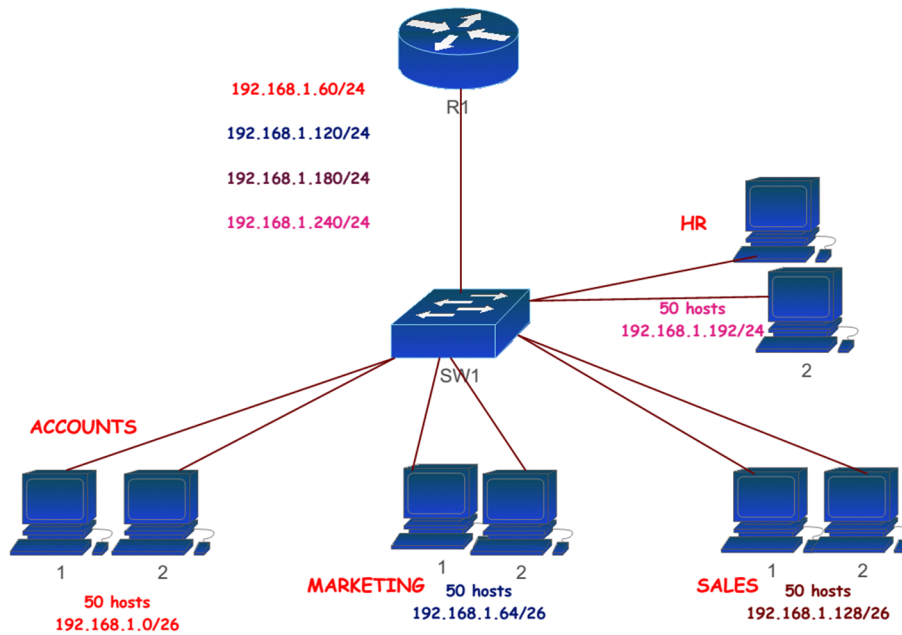
A-class

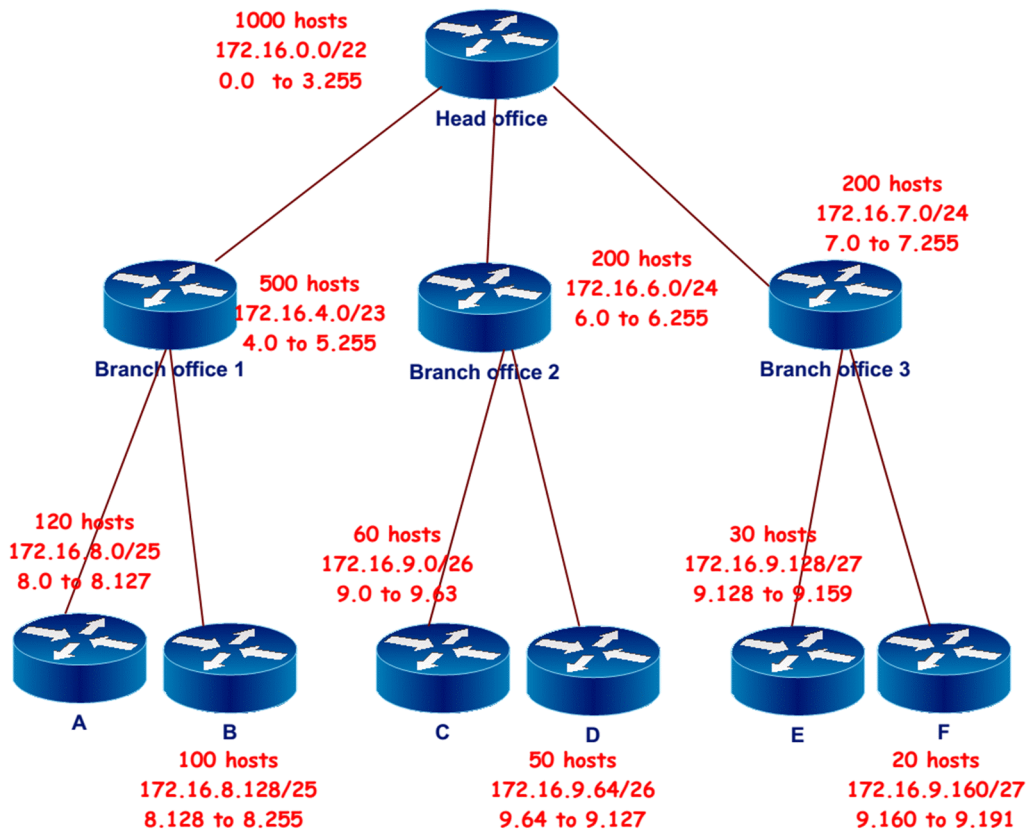
- Req 32000, 8000 , 1000, 500, 200
- Req 4000, 200 , 120 , 60, 30, 12 , 10

VLSM Design Examples

Below you can find some of the sample scenario diagram where it mentions the requirements (ie No of hosts)







Subnetting Questions

Find subnet-mask , Range (network ID and Broadcast ID) , Valid Host, Subnets

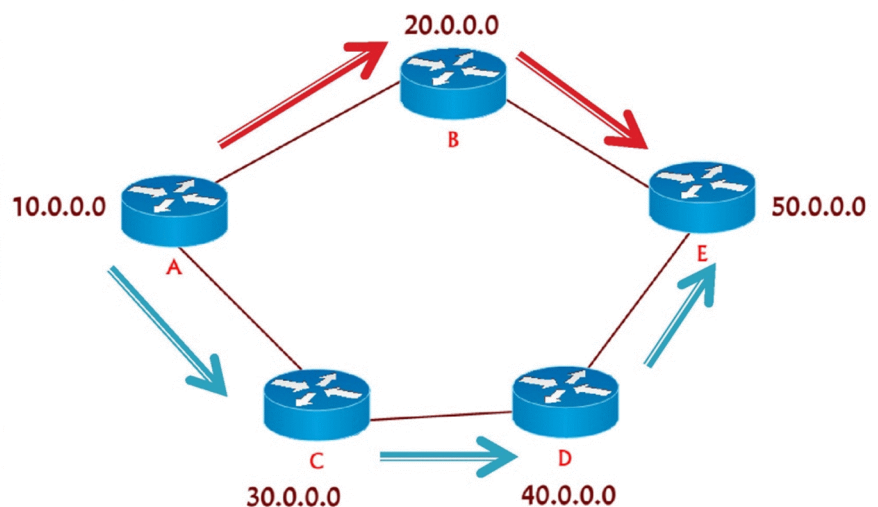
- 192.168.10.145/26
- 200.10.10.215/27
- 150.12.110.10/25
- 112.10.78.40/22
- 50.1.112.10/21
- 28.10.145.10/18
- 150.50.50.50/23
- 100.10.185.10/20
- 172.16.221.10/19

Routing

Static , Dynamic, Default

Routing

- ▶ Forwarding of packets from one network to another network .
- ▶ choosing the best path from the routing table.



Best path selection is based on the type of routing we are using (static /Dynamic)

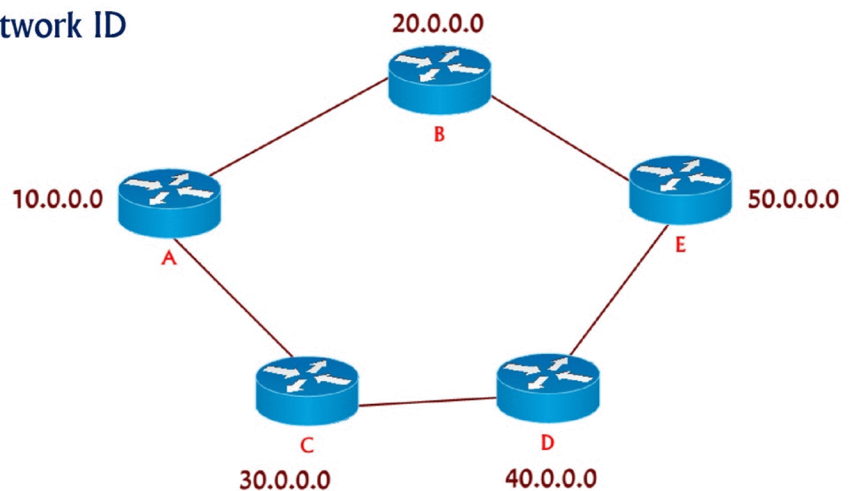
Types of Routing

1. Static Routing
2. Default Routing
3. Dynamic Routing

Static Routing



- ▶ Best path is configured manually by Administrator
- ▶ Mandatory need of Destination Network ID
- ▶ It is Secure & fast



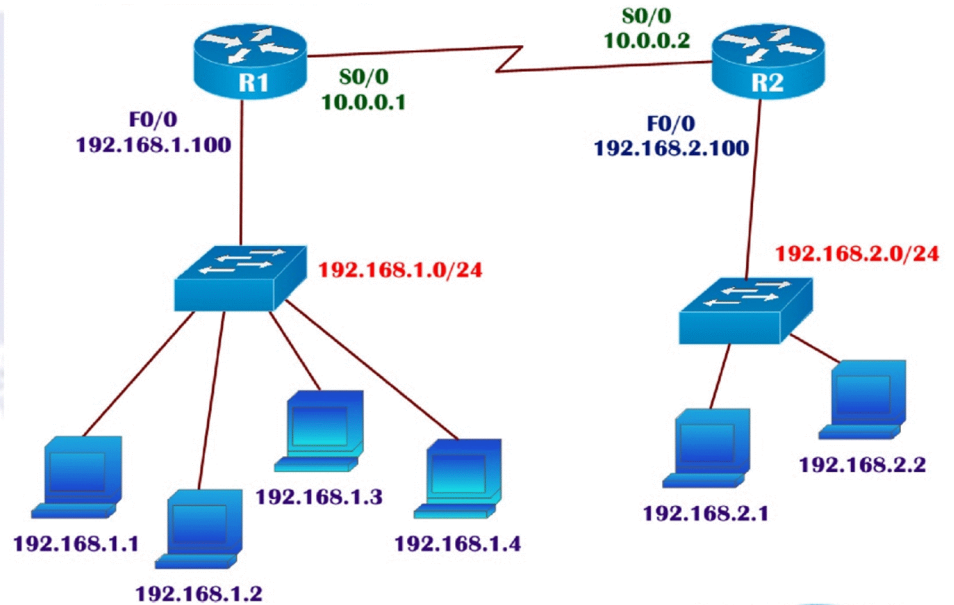
Disadvantages

- Everything to manually
- Used for small network.
- Network change effect complete network.

Configuring Static Route

Router(config)#

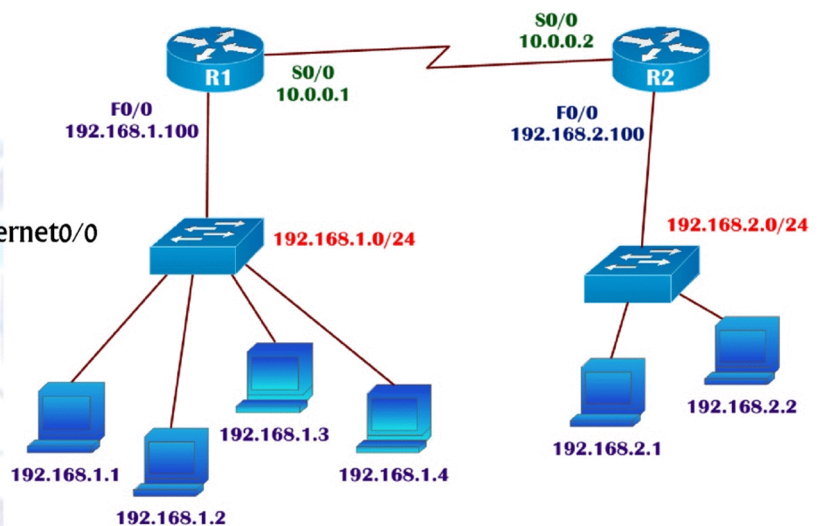
ip route <Destination Network ID> <Destination Subnet Mask> <Next-hop IP address >



Verification before static Routing

R-1#show ip route

C 10.0.0.0/8 is directly connected, Serial0/0
C 192.168.1.0/24 is directly connected, FastEthernet0/0



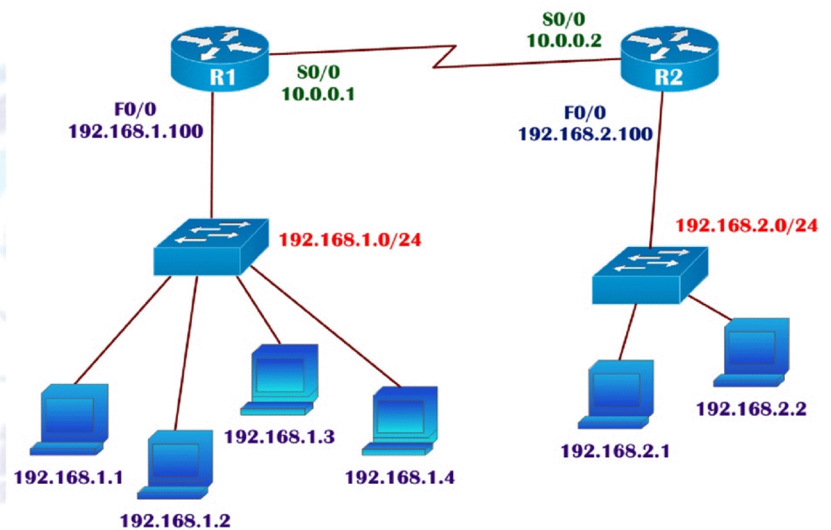
PC>ping 192.168.2.1

Pinging 192.168.2.1 with 32 bytes of data:

Reply from 192.168.1.100: Destination host unreachable.
Reply from 192.168.1.100: Destination host unreachable.
Reply from 192.168.1.100: Destination host unreachable.
Reply from 192.168.1.100: Destination host unreachable.

Static Routing – 2 routers

R-1(config)# ip route 192.168.2.0 255.255.255.0 10.0.0.2



R-1#sh ip route

Gateway of last resort is not set

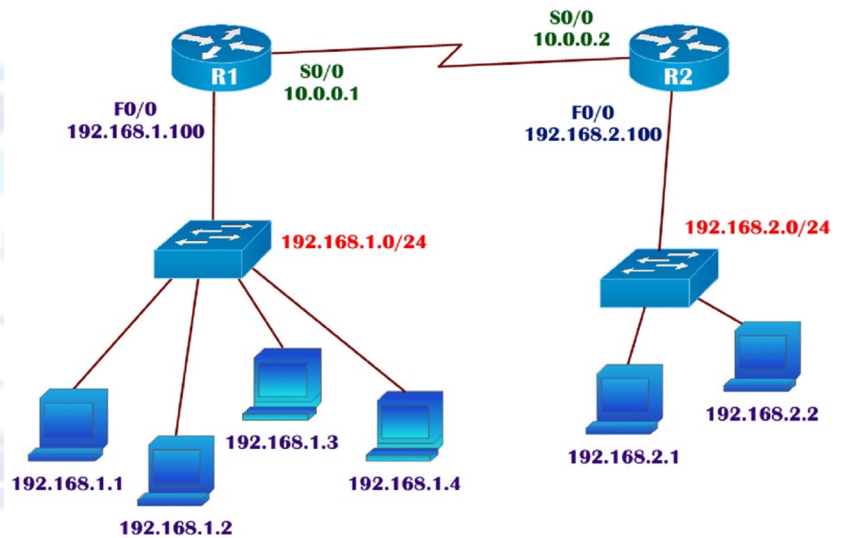
C 10.0.0.0/8 is directly connected, Serial0/0

C 192.168.1.0/24 is directly connected, FastEthernet0/0

S 192.168.2.0/24 [1/0] via 10.0.0.2

Static Routing – 2 routers

R-2(config)#ip route 192.168.1.0 255.255.255.0 10.0.0.1



R-2#show ip route

Gateway of last resort is not set

C 10.0.0.0/8 is directly connected, Serial0/0

S 192.168.1.0/24 [1/0] via 10.0.0.1

C 192.168.2.0/24 is directly connected, FastEthernet0/0

Ping & tracert

PC>ping 192.168.2.1

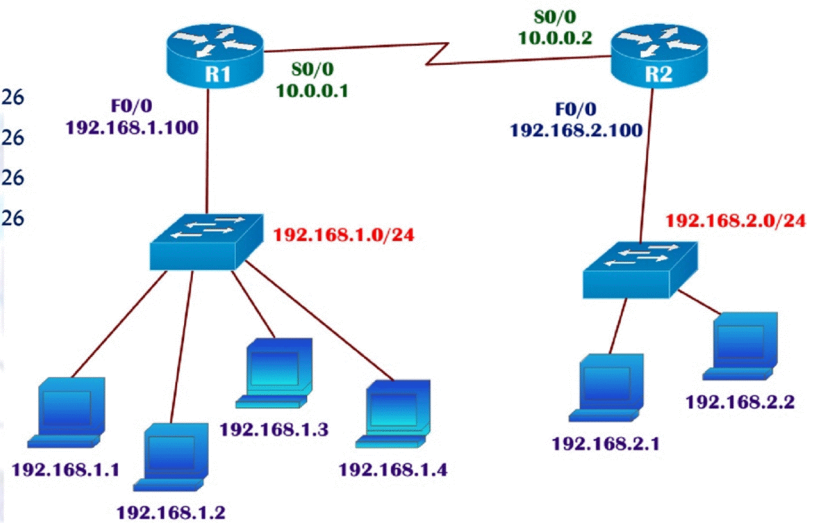
Pinging 192.168.2.1 with 32 bytes of data:

Reply from 192.168.2.1: bytes=32 time=20ms TTL=126

Reply from 192.168.2.1: bytes=32 time=20ms TTL=126

Reply from 192.168.2.1: bytes=32 time=21ms TTL=126

Reply from 192.168.2.1: bytes=32 time=21ms TTL=126



PC>tracert 192.168.2.1

Tracing route to 192.168.2.1 over a maximum of 30 hops:

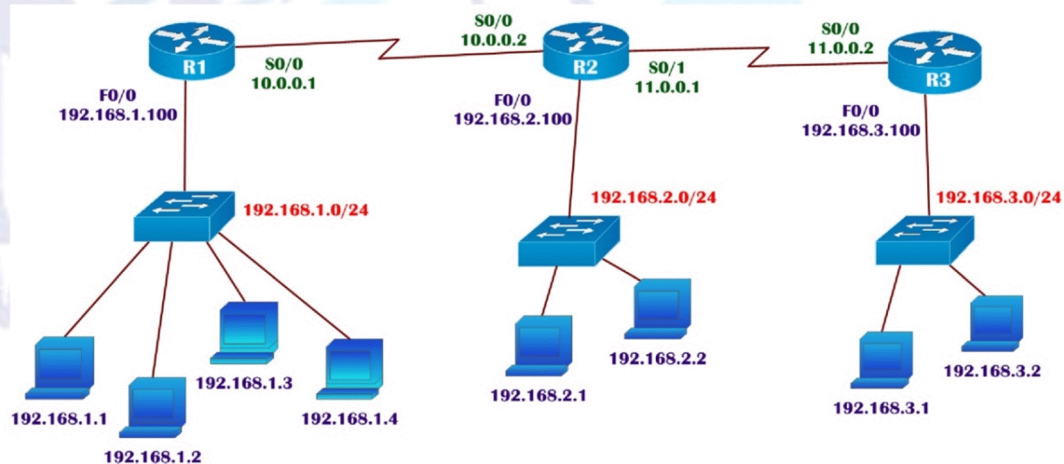
1	44 ms	9 ms	10 ms	192.168.1.100
2	13 ms	13 ms	12 ms	10.0.0.2
3	17 ms	22 ms	20 ms	192.168.2.1

Static Routing – 3 routers

R-1(config)# ip route 192.168.2.0 255.255.255.0 10.0.0.2

R-1(config)# ip route 192.168.3.0 255.255.255.0 10.0.0.2

R-1(config)# ip route 11.0.0.0 255.0.0.0 10.0.0.2



Static Routing - 3 routers

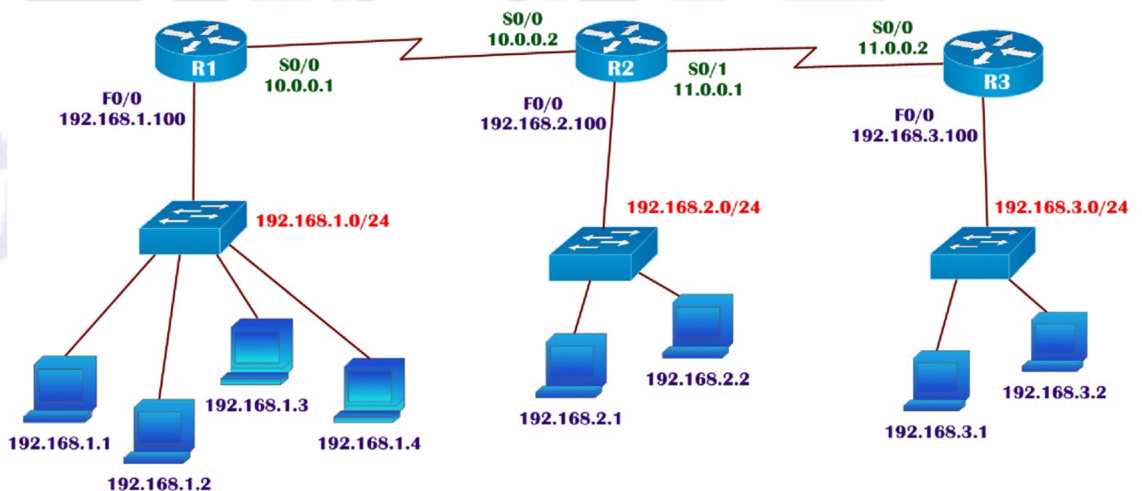
R-2(config)# ip route 192.168.1.0 255.255.255.0 10.0.0.1

R-2(config)# ip route 192.168.3.0 255.255.255.0 11.0.0.2

R-3(config)# ip route 192.168.2.0 255.255.255.0 11.0.0.1

R-3(config)# ip route 192.168.1.0 255.255.255.0 11.0.0.1

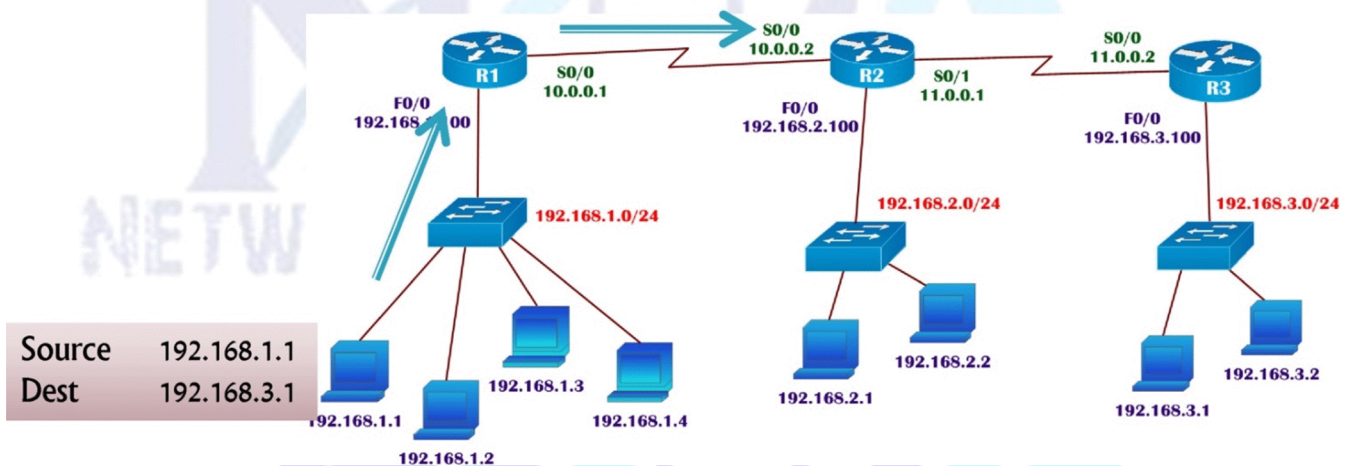
R-3(config)# ip route 10.0.0.0 255.0.0.0 11.0.0.1



Routing lookup

R-1#sh ip route

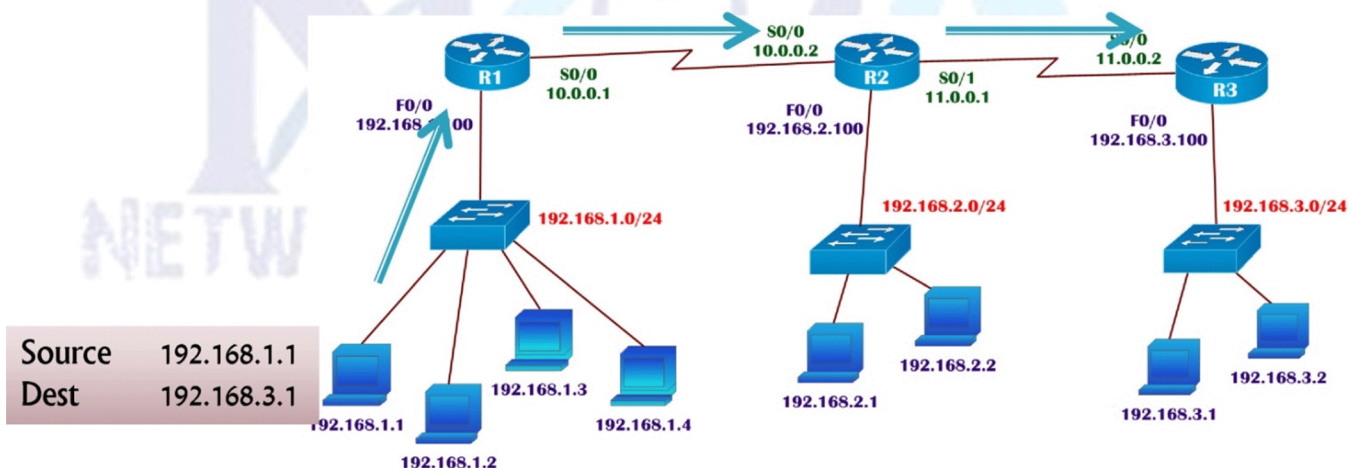
```
C 10.0.0.0/8 is directly connected, Serial0/0
S 11.0.0.0/8 [1/0] via 10.0.0.2
C 192.168.1.0/24 is directly connected, FastEthernet0/0
S 192.168.2.0/24 [1/0] via 10.0.0.2
S 192.168.3.0/24 [1/0] via 10.0.0.2
```



Routing lookup

R-2#sh ip route

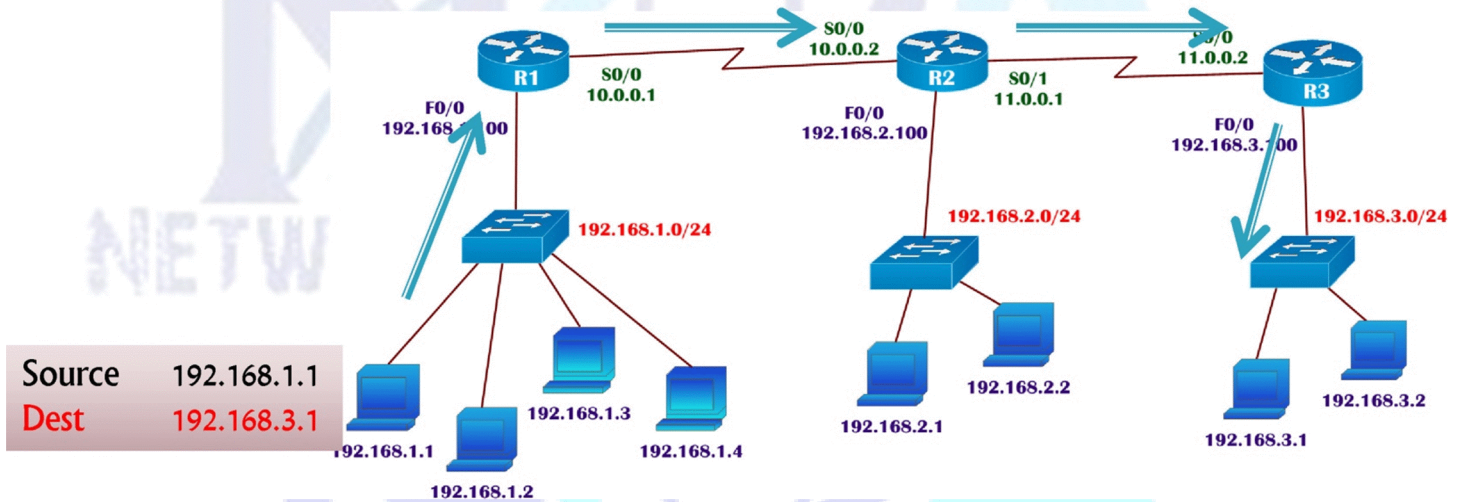
```
C 10.0.0.0/8 is directly connected, Serial0/0
C 11.0.0.0/8 is directly connected, Serial0/1
S 192.168.1.0/24 [1/0] via 10.0.0.1
C 192.168.2.0/24 is directly connected, FastEthernet0/0
S 192.168.3.0/24 [1/0] via 11.0.0.2
```



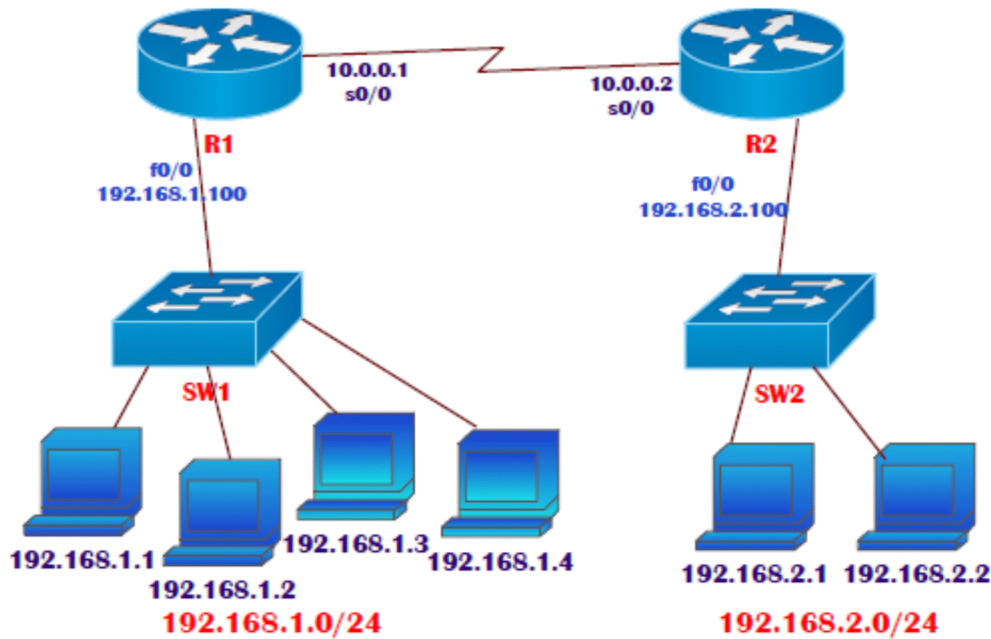
Routing lookup

R-3#sh ip route

```
S 10.0.0.0/8 [1/0] via 11.0.0.1
C 11.0.0.0/8 is directly connected, Serial0/0
S 192.168.1.0/24 [1/0] via 11.0.0.1
S 192.168.2.0/24 [1/0] via 11.0.0.1
C 192.168.3.0/24 is directly connected, FastEthernet0/0
```



LAB: STATIC ROUTING



Pre-requirement for LAB (check previous labs)

- Design the topology (connectivity)
- Assign the IP address according to diagram
- Make sure that interfaces used should be in UP UP state

TASK:

- Configure Static routing
- Verify Routing table and reachability between the LAN's (using PING and TRACE commands)

R-1#show ip route

Gateway of last resort is not set

C 10.0.0.0/8 is directly connected, Serial0/0

C 192.168.1.0/24 is directly connected, FastEthernet0/0

R-2#show ip route

Gateway of last resort is not set

C 10.0.0.0/8 is directly connected, Serial0/0

C 192.168.2.0/24 is directly connected, FastEthernet0/0

NOTE:

- The above routing table displays only the networks which are directly connected
- By default router don't know about the networks which are not directly connected and that the reason there is no reachability between the two LAN's
- So to provide reachability we need to implement any type of the routing

PC> ipconfig

IP Address.....: 192.168.1.1
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 192.168.1.100

PC>ping 192.168.2.1

Pinging 192.168.2.1 with 32 bytes of data:

Reply from 192.168.1.100: Destination host unreachable.
Reply from 192.168.1.100: Destination host unreachable.
Reply from 192.168.1.100: Destination host unreachable.
Reply from 192.168.1.100: Destination host unreachable.

Ping statistics for 192.168.2.1:

Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),

- From the above output we can see there is no communication between 192.168.1.1 and 192.168.2.1 and they are on different networks.
- In order to communicate we need to implement any of the routing (here in this we use static routing)

On R-1

R-1(config)# ip route 192.168.2.0 255.255.255.0 10.0.0.2
R-1(config)# end

R-1#sh ip route

Gateway of last resort is not set

C 10.0.0.0/8 is directly connected, Serial0/0
C 192.168.1.0/24 is directly connected, FastEthernet0/0
S 192.168.2.0/24 [1/0] via 10.0.0.2

On R-2

R-2(config)#ip route 192.168.1.0 255.255.255.0 10.0.0.1
R-2(config)#end

R-2#show ip route

Gateway of last resort is not set

C 10.0.0.0/8 is directly connected, Serial0/0
S 192.168.1.0/24 [1/0] via 10.0.0.1
C 192.168.2.0/24 is directly connected, FastEthernet0/0

PC>ipconfig

IP Address.....: 192.168.1.1
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 192.168.1.100

PC>ping 192.168.2.1

Pinging 192.168.2.1 with 32 bytes of data:

Request timed out.

Reply from 192.168.2.1: bytes=32 time=20ms TTL=126

Reply from 192.168.2.1: bytes=32 time=21ms TTL=126

Reply from 192.168.2.1: bytes=32 time=21ms TTL=126

PC>ping 192.168.2.2

Pinging 192.168.2.2 with 32 bytes of data:

Request timed out.

Reply from 192.168.2.2: bytes=32 time=21ms TTL=126

Reply from 192.168.2.2: bytes=32 time=19ms TTL=126

Reply from 192.168.2.2: bytes=32 time=12ms TTL=126

PC>tracert 192.168.2.1

Tracing route to 192.168.2.1 over a maximum of 30 hops:

1	44 ms	9 ms	10 ms	192.168.1.100
2	13 ms	13 ms	12 ms	10.0.0.2
3	17 ms	22 ms	20 ms	192.168.2.1

R-2#ping 192.168.1.1

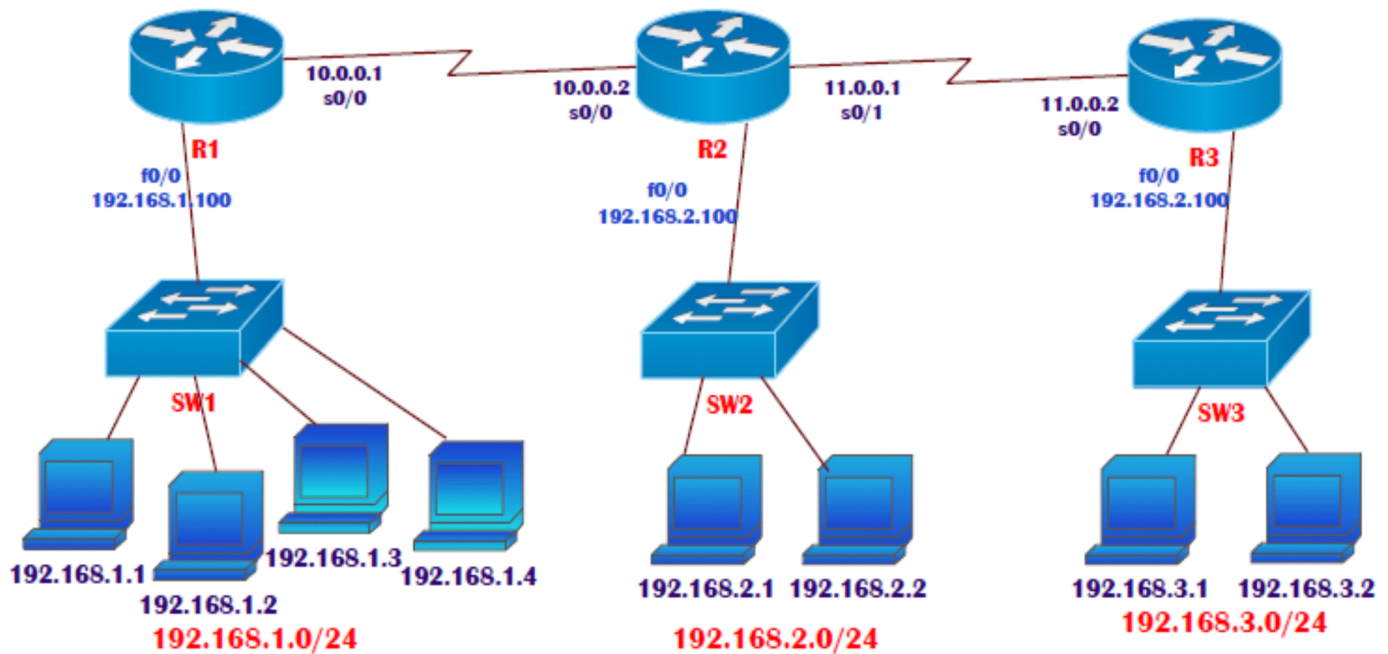
Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 10/15/18 ms

LAB: STATIC ROUTING USING THREE ROUTERS



Pre-requirement for LAB (check previous labs)

- Design the topology (connectivity)
- Assign the IP address according to diagram
- Make sure that interfaces used should be in UP UP state

TASK:

- Configure Static routing
- Verify Routing table and reachability between the LAN's (using PING and TRACE commands)

R-1#sh ip route

Gateway of last resort is not set

C 10.0.0.0/8 is directly connected, Serial0/0

C 192.168.1.0/24 is directly connected, FastEthernet0/0

R-2#sh ip route

Gateway of last resort is not set

C 10.0.0.0/8 is directly connected, Serial0/0

C 11.0.0.0/8 is directly connected, Serial0/1

C 192.168.2.0/24 is directly connected, FastEthernet0/0

R-3#sh ip route

Gateway of last resort is not set

C 11.0.0.0/8 is directly connected, Serial0/0

C 192.168.3.0/24 is directly connected, FastEthernet0/0

Router- 1

R-1(config)# ip route 192.168.2.0 255.255.255.0 10.0.0.2

```
R-1(config)# ip route 192.168.3.0 255.255.255.0 10.0.0.2
```

```
R-1(config)# ip route 11.0.0.0 255.0.0.0 10.0.0.2
```

Router – 2

```
R-2(config)# ip route 192.168.1.0 255.255.255.0 10.0.0.1
```

```
R-2(config)# ip route 192.168.3.0 255.255.255.0 11.0.0.2
```

Router – 3

```
R-3(config)# ip route 192.168.2.0 255.255.255.0 11.0.0.1
```

```
R-3(config)# ip route 192.168.1.0 255.255.255.0 11.0.0.1
```

```
R-3(config)# ip route 10.0.0.0 255.0.0.0 11.0.0.1
```

R-1#show ip route

Gateway of last resort is not set

C 10.0.0.0/8 is directly connected, Serial0/0

S 11.0.0.0/8 [1/0] via 10.0.0.2

C 192.168.1.0/24 is directly connected, FastEthernet0/0

S 192.168.2.0/24 [1/0] via 10.0.0.2

S 192.168.3.0/24 [1/0] via 10.0.0.2

R-2#show ip route

C 10.0.0.0/8 is directly connected, Serial0/0

C 11.0.0.0/8 is directly connected, Serial0/1

S 192.168.1.0/24 [1/0] via 10.0.0.1

C 192.168.2.0/24 is directly connected, FastEthernet0/0

S 192.168.3.0/24 [1/0] via 11.0.0.2

R-3#show ip route

S 10.0.0.0/8 [1/0] via 11.0.0.1

C 11.0.0.0/8 is directly connected, Serial0/0

S 192.168.1.0/24 [1/0] via 11.0.0.1

S 192.168.2.0/24 [1/0] via 11.0.0.1

C 192.168.3.0/24 is directly connected, FastEthernet0/0

PC>ipconfig

IP Address.....: 192.168.1.1

Subnet Mask.....: 255.255.255.0

Default Gateway.....: 192.168.1.100

PC>ping 192.168.2.1

Pinging 192.168.2.1 with 32 bytes of data:

Request timed out.

Reply from 192.168.2.1: bytes=32 time=19ms TTL=126

Reply from 192.168.2.1: bytes=32 time=20ms TTL=126

Reply from 192.168.2.1: bytes=32 time=14ms TTL=126

PC>ping 192.168.3.1

Pinging 192.168.3.1 with 32 bytes of data:

Request timed out.

Reply from 192.168.3.1: bytes=32 time=27ms TTL=125

Reply from 192.168.3.1: bytes=32 time=22ms TTL=125

Reply from 192.168.3.1: bytes=32 time=25ms TTL=125

PC>tracert 192.168.3.1

Tracing route to 192.168.3.1 over a maximum of 30 hops:

1	5 ms	8 ms	8 ms	192.168.1.100
2	12 ms	9 ms	8 ms	10.0.0.2
3	17 ms	6 ms	12 ms	11.0.0.2
4	24 ms	27 ms	25 ms	192.168.3.1

Trace complete.

R-1#ping 192.168.3.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.3.1, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 9/16/31 ms

R-3#ping 192.168.1.1

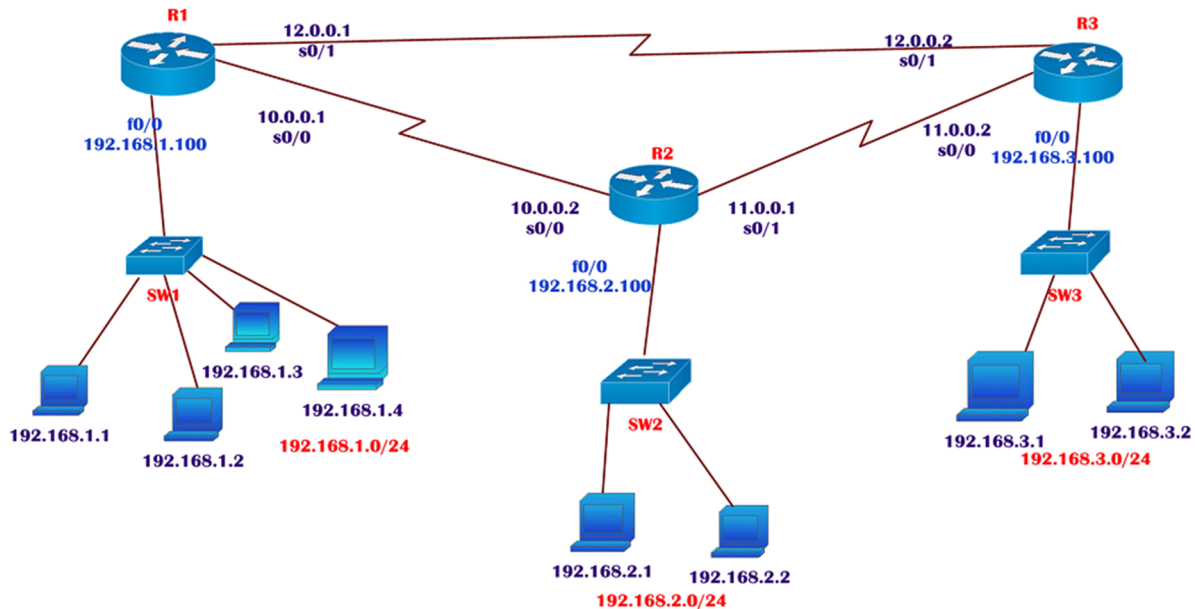
Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 10/15/18 ms

LAB: Static Routing – Redundant links



TASK:

- Continue with the same configurations done in the previous lab.
- Connect R1 – R3 WAN link using any of the serial interface and assign ip address as per the diagram.
- Save the topology and configurations for future labs.

R-1#sh ip interface brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.1.100	YES	manual	up	up
FastEthernet0/1	unassigned	YES	unset	administratively down	down
Serial0/0	10.0.0.1	YES	manual	up	up
Serial0/1	unassigned	YES	unset	administratively down	down

R-3#sh ip interface brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.3.100	YES	manual	up	up
FastEthernet0/1	unassigned	YES	unset	administratively down	down
Serial0/0	11.0.0.2	YES	manual	up	up
Serial0/1	unassigned	YES	unset	administratively down	down

R-1(config-if)#interface serial 0/1

R-1(config-if)#ip address 12.0.0.1 255.0.0.0

R-1(config-if)#no shutdown

R-1(config-if)#clock rate 64000

R-1(config-if)#end

R-1#sh ip int brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.1.100	YES	manual	up	up
FastEthernet0/1	unassigned	YES	unset	administratively down	down
Serial0/0	10.0.0.1	YES	manual	up	up
Serial0/1	12.0.0.1	YES	manual	down	down

```
R-3(config)#int serial 0/1
R-3(config-if)#ip address 12.0.0.2 255.0.0.0
R-3(config-if)#no shutdown
R-3(config-if)#end
```

R-3#sh ip int brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.3.100	YES	manual	up	up
FastEthernet0/1	unassigned	YES	unset	administratively down	down
Serial0/0	11.0.0.2	YES	manual	up	up
Serial0/1	12.0.0.2	YES	manual	up	up

R-3#ping 12.0.0.1

```
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 12.0.0.1, timeout is 2 seconds:
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 5/11/28 ms
```

R-3#sh ip route

```
Gateway of last resort is not set

S  10.0.0.0/8 [1/0] via 11.0.0.1
C  11.0.0.0/8 is directly connected, Serial0/0
C  12.0.0.0/8 is directly connected, Serial0/1
S  192.168.1.0/24 [1/0] via 11.0.0.1
S  192.168.2.0/24 [1/0] via 11.0.0.1
C  192.168.3.0/24 is directly connected, FastEthernet0/0
```

R-1#sh ip route

```
Gateway of last resort is not set

C  10.0.0.0/8 is directly connected, Serial0/0
S  11.0.0.0/8 [1/0] via 10.0.0.2
C  12.0.0.0/8 is directly connected, Serial0/1
C  192.168.1.0/24 is directly connected, FastEthernet0/0
S  192.168.2.0/24 [1/0] via 10.0.0.2
S  192.168.3.0/24 [1/0] via 10.0.0.2
```

PC>ipconfig

```
FastEthernet0 Connection:(default port)

Link-local IPv6 Address.....: FE80::210:11FF:FE3B:B4D1
IP Address.....: 192.168.1.1
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 192.168.1.100
```

PC>ping 192.168.2.1

```
Pinging 192.168.2.1 with 32 bytes of data:

Request timed out.
```


Reply from 192.168.2.1: bytes=32 time=1ms TTL=126
Reply from 192.168.2.1: bytes=32 time=2ms TTL=126
Reply from 192.168.2.1: bytes=32 time=21ms TTL=126

Ping statistics for 192.168.2.1:

Packets: Sent = 4, Received = 3, Lost = 1 (25% loss),
Approximate round trip times in milli-seconds:
Minimum = 1ms, Maximum = 21ms, Average = 8ms

PC>ping 192.168.3.1

Pinging 192.168.3.1 with 32 bytes of data:

Request timed out.

Reply from 192.168.3.1: bytes=32 time=6ms TTL=125
Reply from 192.168.3.1: bytes=32 time=2ms TTL=125
Reply from 192.168.3.1: bytes=32 time=2ms TTL=125

Ping statistics for 192.168.3.1:

Packets: Sent = 4, Received = 3, Lost = 1 (25% loss),
Approximate round trip times in milli-seconds:
Minimum = 2ms, Maximum = 6ms, Average = 3ms

PC>tracert 192.168.2.1

Tracing route to 192.168.2.1 over a maximum of 30 hops:

1	0 ms	0 ms	0 ms	192.168.1.100
2	1 ms	0 ms	0 ms	10.0.0.2
3	0 ms	1 ms	1 ms	192.168.2.1

Trace complete.

PC>tracert 192.168.3.1

Tracing route to 192.168.3.1 over a maximum of 30 hops:

1	0 ms	0 ms	0 ms	192.168.1.100
2	0 ms	0 ms	1 ms	10.0.0.2
3	1 ms	0 ms	0 ms	11.0.0.2
4	17 ms	0 ms	0 ms	192.168.3.1

Trace complete.

As per the static Routing configured in the previous lab

- To reach R1- R2 LAN uses path via R1-R2
- To reach R1-R3 LAN uses path via R1-R2-R3

TASK:

- Shutdown the link between R1-R2 (Here we are assuming the link goes down)

```
R-1(config)#int s0/0
R-1(config-if)#shutdown
R-1(config-if)#end
```

```
R-1#sh ip route
```

Gateway of last resort is not set

```
C 12.0.0.0/8 is directly connected, Serial0/1
C 192.168.1.0/24 is directly connected, FastEthernet0/0
```

- Shutting down the link between R1-R2 will automatically removes the static route from the R1 as the static route are configured via s0/0 interface as the next-hop is not reachable
- The major drawback is if the route goes down the administrator has to manually change the route on all the routers

```
R-1(config)#no ip route 192.168.2.0 255.255.255.0 10.0.0.2
R-1(config)#no ip route 192.168.3.0 255.255.255.0 10.0.0.2
R-1(config)#no ip route 11.0.0.0 255.0.0.0 10.0.0.2
```

```
R-1(config)#ip route 11.0.0.0 255.0.0.0 12.0.0.2
R-1(config)#ip route 192.168.2.0 255.255.255.0 12.0.0.2
R-1(config)#ip route 192.168.3.0 255.255.255.0 12.0.0.2
```

```
R-2#sh ip interface brief
```

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.2.100	YES	manual	up	up
FastEthernet0/1	unassigned	YES	unset	administratively down	down
Serial0/0	10.0.0.2	YES	manual	down	down
Serial0/1	11.0.0.1	YES	manual	up	up

```
R-2#sh ip route
```

```
Gateway of last resort is not set
C 11.0.0.0/8 is directly connected, Serial0/1
C 192.168.2.0/24 is directly connected, FastEthernet0/0
S 192.168.3.0/24 [1/0] via 11.0.0.2
```

```
R-2(config)#no ip route 192.168.1.0 255.255.255.0 10.0.0.1
R-2(config)# ip route 12.0.0.0 255.0.0.0 11.0.0.2
R-2(config)# ip route 192.168.1.0 255.255.255.0 11.0.0.2
```

```
R-2#sh ip route
```

```
Gateway of last resort is not set

C 11.0.0.0/8 is directly connected, Serial0/1
S 12.0.0.0/8 [1/0] via 11.0.0.2
S 192.168.1.0/24 [1/0] via 11.0.0.2
C 192.168.2.0/24 is directly connected, FastEthernet0/0
S 192.168.3.0/24 [1/0] via 11.0.0.2
```

```
R-3#sh ip route
```

Gateway of last resort is not set

```
S 10.0.0.0/8 [1/0] via 11.0.0.1
C 11.0.0.0/8 is directly connected, Serial0/0
C 12.0.0.0/8 is directly connected, Serial0/1
S 192.168.1.0/24 [1/0] via 11.0.0.1
S 192.168.2.0/24 [1/0] via 11.0.0.1
C 192.168.3.0/24 is directly connected, FastEthernet0/0
```

- Here the routes are still in the routing table, but the reachability to 192.168.1.0 will not work.
- As R3 send to R2 and R2 sends back to R3 as per the routing table manually configured.
- To verify use tracer command on PC from 192.168.3.1 to 192.168.1.1

PC>ipconfig

FastEthernet0 Connection:(default port)

Link-local IPv6 Address.....: FE80::200:CFF:FE6A:98CA
IP Address.....: 192.168.3.1
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 192.168.3.100

PC>tracert 192.168.1.1

Tracing route to 192.168.1.1 over a maximum of 30 hops:

1	1 ms	0 ms	1 ms	192.168.3.100
2	2 ms	0 ms	3 ms	11.0.0.1
3	1 ms	0 ms	1 ms	192.168.3.100
4	4 ms	0 ms	1 ms	11.0.0.1
5	1 ms	1 ms	5 ms	192.168.3.100
6	11 ms	11 ms	11 ms	11.0.0.1
7	1 ms	0 ms	16 ms	192.168.3.100
8	13 ms	11 ms	13 ms	11.0.0.1
9	10 ms	13 ms	13 ms	192.168.3.100
10	12 ms	12 ms	12 ms	11.0.0.1
11	13 ms	16 ms	12 ms	192.168.3.100
12	12 ms	12 ms	18 ms	11.0.0.1
13	12 ms	6 ms	12 ms	192.168.3.100
14	16 ms	12 ms	12 ms	11.0.0.1
15	12 ms	12 ms	13 ms	192.168.3.100
16	22 ms	22 ms	14 ms	11.0.0.1
17	11 ms	12 ms	18 ms	192.168.3.100
18	16 ms	25 ms	23 ms	11.0.0.1
19	23 ms	22 ms	22 ms	192.168.3.100

20

Control-C

^C

R-3(config)#no ip route 192.168.1.0 255.255.255.0 11.0.0.1

R-3(config)#ip route 192.168.1.0 255.255.255.0 12.0.0.1

R-3#sh ip route

Gateway of last resort is not set


```
S 10.0.0.0/8 [1/0] via 11.0.0.1
C 11.0.0.0/8 is directly connected, Serial0/0/0
C 12.0.0.0/8 is directly connected, Serial0/0/1
S 192.168.1.0/24 [1/0] via 12.0.0.1
S 192.168.2.0/24 [1/0] via 11.0.0.1
C 192.168.3.0/24 is directly connected, FastEthernet0/0
```

PC>ipconfig

FastEthernet0 Connection:(default port)

Link-local IPv6 Address.....: FE80::200:CFF:FE6A:98CA
IP Address.....: 192.168.3.1
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 192.168.3.100

PC>ping 192.168.1.1

Pinging 192.168.1.1 with 32 bytes of data:
Reply from 192.168.1.1: bytes=32 time=1ms TTL=126
Reply from 192.168.1.1: bytes=32 time=1ms TTL=126
Reply from 192.168.1.1: bytes=32 time=3ms TTL=126
Reply from 192.168.1.1: bytes=32 time=1ms TTL=126

Ping statistics for 192.168.1.1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
Minimum = 1ms, Maximum = 3ms, Average = 1ms

PC>tracert 192.168.1.1

Tracing route to 192.168.1.1 over a maximum of 30 hops:

1	1 ms	0 ms	0 ms	192.168.3.100
2	1 ms	0 ms	0 ms	12.0.0.1
3	1 ms	0 ms	0 ms	192.168.1.1

Trace complete.

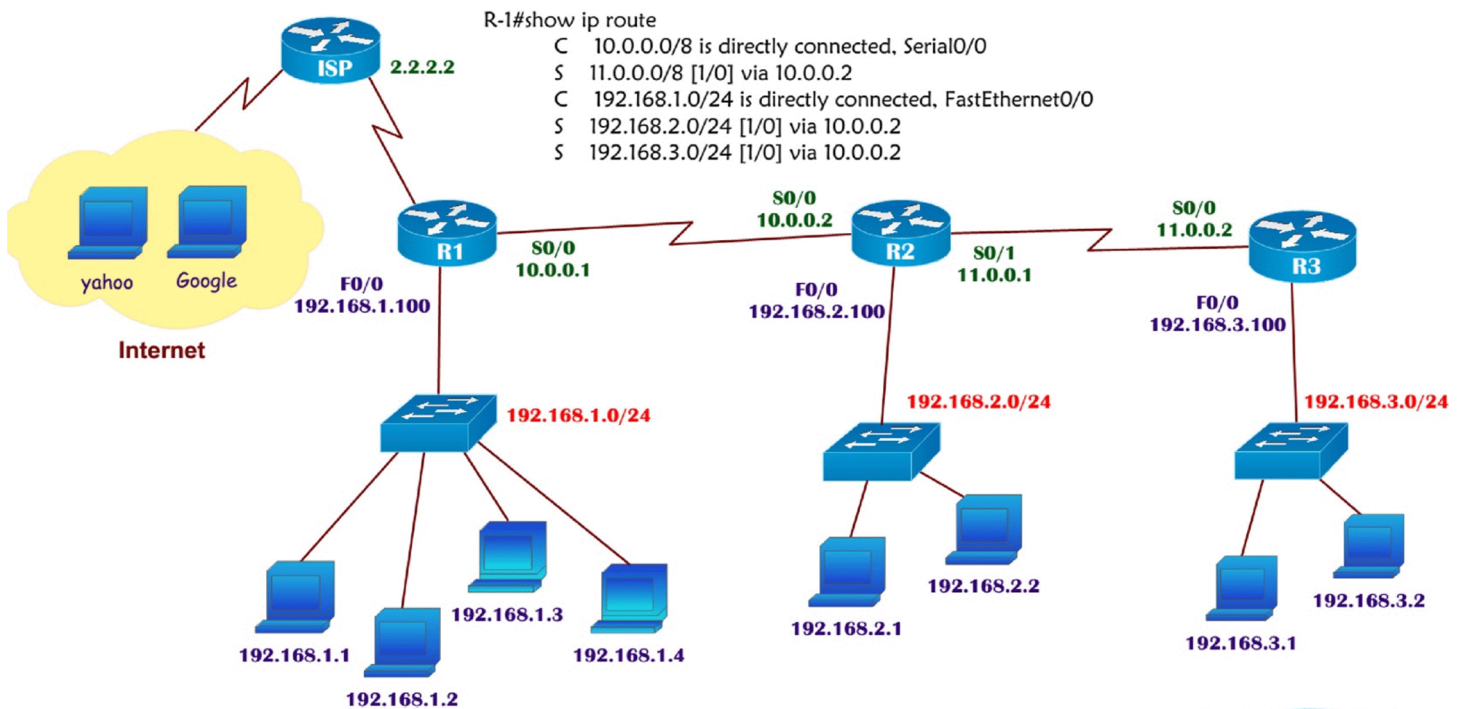
PC>ping 192.168.2.1

Pinging 192.168.2.1 with 32 bytes of data:

Reply from 192.168.2.1: bytes=32 time=1ms TTL=126
Reply from 192.168.2.1: bytes=32 time=1ms TTL=126
Reply from 192.168.2.1: bytes=32 time=3ms TTL=126
Reply from 192.168.2.1: bytes=32 time=1ms TTL=126

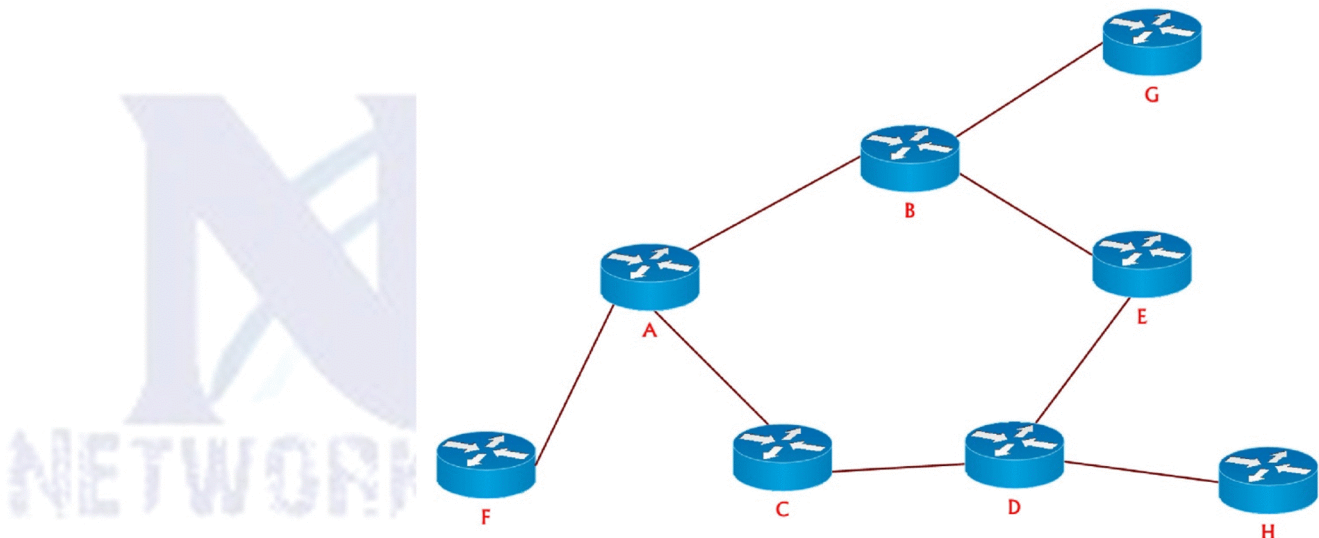
Default Routing

Used to route traffic for unknown destinations (internet)



Default Routing

Also can be used at end locations.(optional)



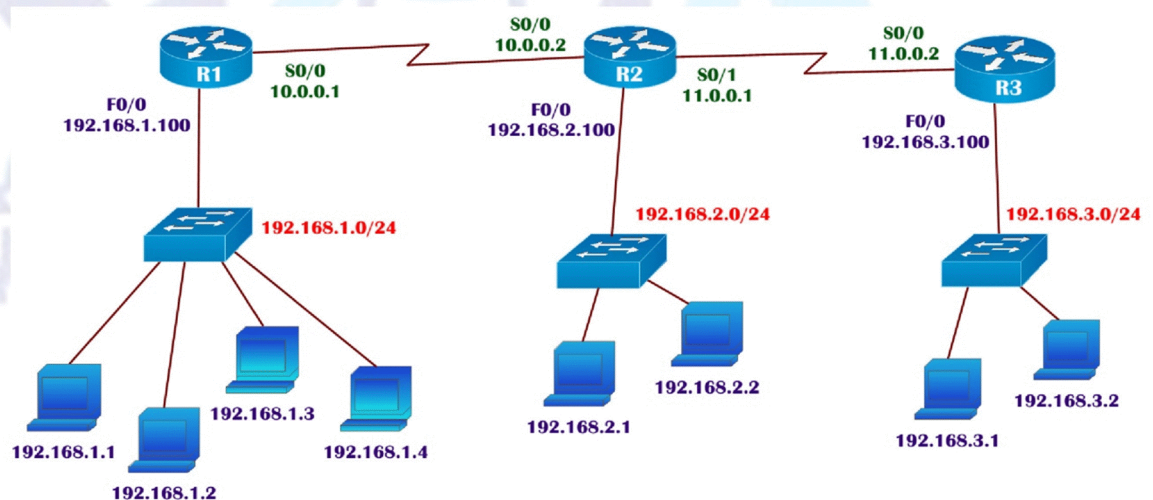
Default Routing (contd)

- ▶ It is the last preferred routing
- ▶ Default routes help in reducing the size of your routing table.
- ▶ R-1(config)#ip route 0.0.0.0 0.0.0.0 10.0.0.2

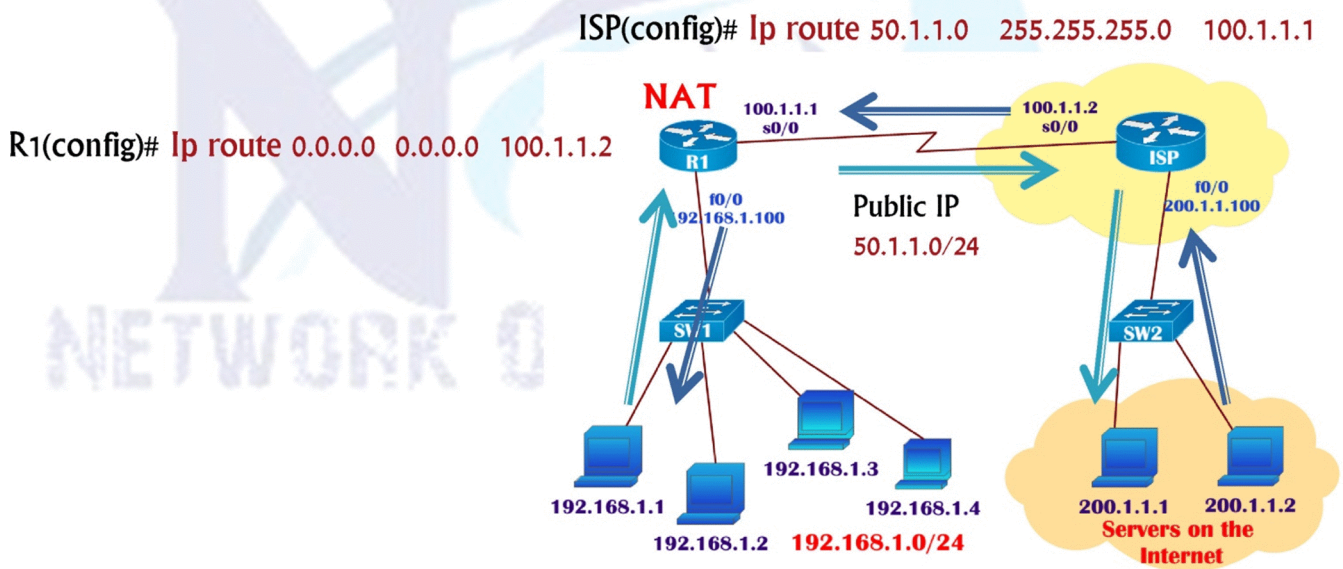
LAB: Verifying Default Route

Task:

- ▶ Design topology
- ▶ Basic IP addressing (up up)
- ▶ R1 and R3 configured with default routes (common next-hop for all destinations)
- ▶ R2 using static routing



Default Routing in real world scenario (with NAT)



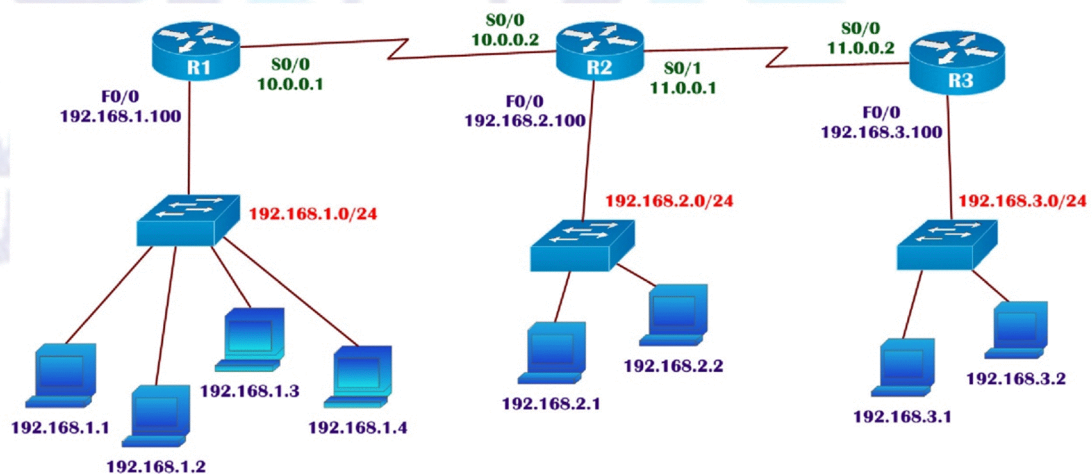
LAB: Verifying Default Route

R-1(config)#ip route 0.0.0.0 0.0.0.0 10.0.0.2

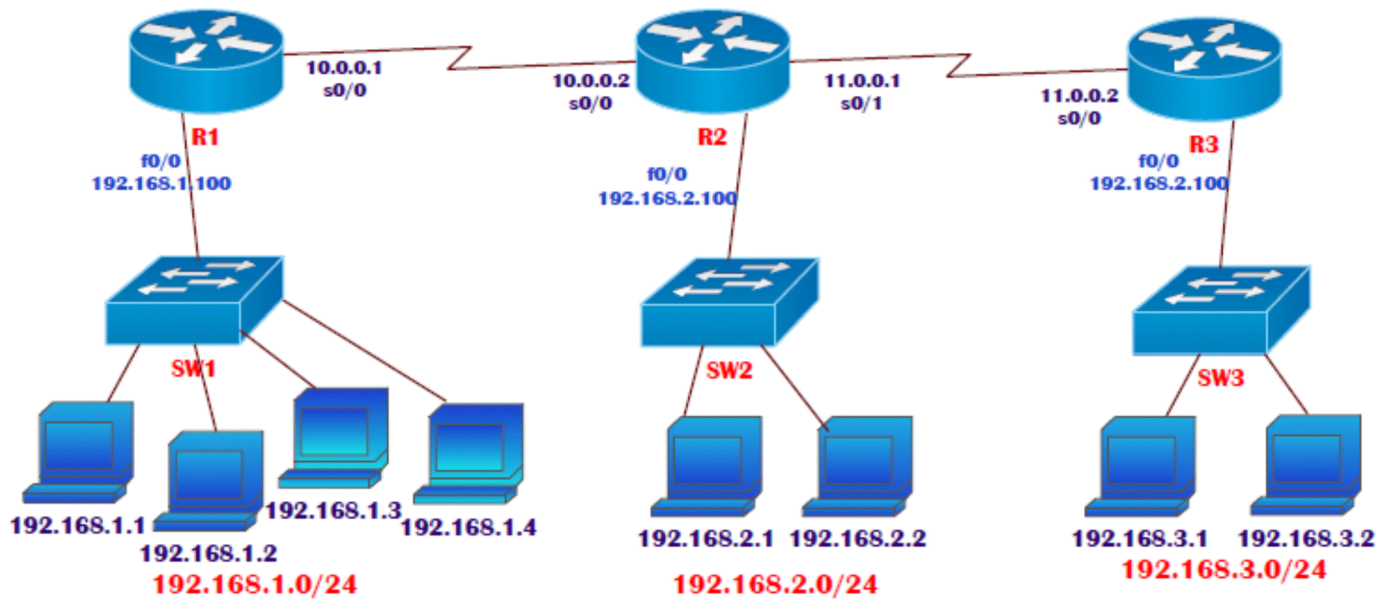
R-2(config)#ip route 192.168.1.0 255.255.255.0 10.0.0.1

R-2(config)#ip route 192.168.3.0 255.255.255.0 11.0.0.2

R-3(config)# ip route 0.0.0.0 0.0.0.0 11.0.0.1



LAB: DEFAULT ROUTING



Pre-requirement for LAB (check previous labs)

- Design the topology (connectivity)
- Assign the IP address according to diagram
- Make sure that interfaces used should be in UP UP state

TASK:

- Configure Default route used on R1 and R3 , static routing on R2
- Verify Routing table and reachability between the LAN's (using PING and TRACE commands)

R-1#sh ip route

Gateway of last resort is not set

C 10.0.0.0/8 is directly connected, Serial0/0

C 192.168.1.0/24 is directly connected, FastEthernet0/0

R-2#sh ip route

Gateway of last resort is not set

C 10.0.0.0/8 is directly connected, Serial0/0

C 11.0.0.0/8 is directly connected, Serial0/1

C 192.168.2.0/24 is directly connected, FastEthernet0/0

R-3#sh ip route

Gateway of last resort is not set

C 11.0.0.0/8 is directly connected, Serial0/0

C 192.168.3.0/24 is directly connected, FastEthernet0/0

Router- 1

R-1(config)#ip route 0.0.0.0 0.0.0.0 10.0.0.2

Router – 2

```
R-2(config)#ip route 192.168.1.0 255.255.255.0 10.0.0.1
```

```
R-2(config)#ip route 192.168.3.0 255.255.255.0 11.0.0.2
```

On Router – 3

```
R-3(config)# ip route 0.0.0.0 0.0.0.0 11.0.0.1
```

```
R-1#sh ip route
```

Gateway of last resort is 10.0.0.2 to network 0.0.0.0

C 10.0.0.0/8 is directly connected, Serial0/0

C 192.168.1.0/24 is directly connected, FastEthernet0/0

S* 0.0.0.0/0 [1/0] via 10.0.0.2

```
R-2#sh ip route
```

Gateway of last resort is not set

C 10.0.0.0/8 is directly connected, Serial0/0

C 11.0.0.0/8 is directly connected, Serial0/1

S 192.168.1.0/24 [1/0] via 10.0.0.1

C 192.168.2.0/24 is directly connected, FastEthernet0/0

S 192.168.3.0/24 [1/0] via 11.0.0.2

```
R-3#sh ip route
```

Gateway of last resort is 11.0.0.1 to network 0.0.0.0

C 11.0.0.0/8 is directly connected, Serial0/0

C 192.168.3.0/24 is directly connected, FastEthernet0/0

S* 0.0.0.0/0 [1/0] via 11.0.0.1

```
PC>ipconfig
```

IP Address.....: 192.168.1.1

Subnet Mask.....: 255.255.255.0

Default Gateway.....: 192.168.1.100

```
PC>ping 192.168.2.1
```

Pinging 192.168.2.1 with 32 bytes of data:

Request timed out.

Reply from 192.168.2.1: bytes=32 time=19ms TTL=126

Reply from 192.168.2.1: bytes=32 time=20ms TTL=126

Reply from 192.168.2.1: bytes=32 time=14ms TTL=126

```
PC>ping 192.168.3.1
```

Pinging 192.168.3.1 with 32 bytes of data:

Request timed out.

Reply from 192.168.3.1: bytes=32 time=27ms TTL=125

Reply from 192.168.3.1: bytes=32 time=22ms TTL=125

Reply from 192.168.3.1: bytes=32 time=25ms TTL=125

PC>tracert 192.168.3.1

Tracing route to 192.168.3.1 over a maximum of 30 hops:

1	5 ms	8 ms	8 ms	192.168.1.100
2	12 ms	9 ms	8 ms	10.0.0.2
3	17 ms	6 ms	12 ms	11.0.0.2
4	24 ms	27 ms	25 ms	192.168.3.1

Trace complete.

R-1#ping 192.168.3.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.3.1, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 9/16/31 ms

R-3#ping 192.168.1.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 10/15/18 ms

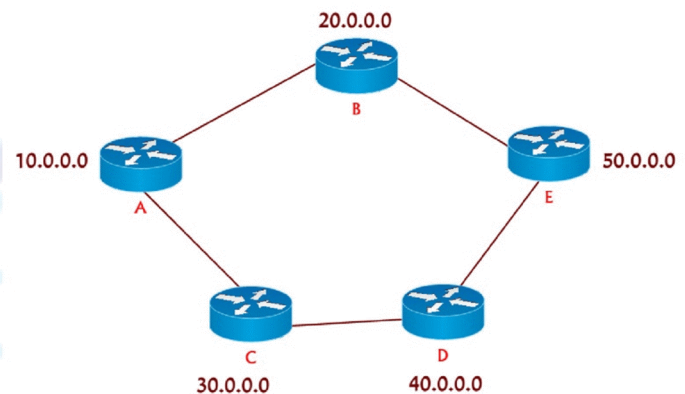
Test your Skills:

- Define routing process and why we do we need Routing?
- Define static routing, Advantages and dis-advantages?
- Write down the syntax for static routing?
- What is the difference between ping and tracert commands used for testing?
- Explain the routing lookup process?
- What is default routing & what are the scenarios where default routing is more applicable?
- Draw the real world scenario where default routing is used (with NAT).

Dynamic Routing

RIP, EIGRP, OSPF

Dynamic Routing



Advantages of Dynamic over static :

- No need of manual configuration (unlike static routing)
- Learns about other networks via advertisements (of directly connected networks)
- Automatically select the best route. (builds routing table)
- Updates the topology changes dynamically.
- No need to know the destination networks. (others network)
- Administrative work is reduced
- Applicable for large organizations.

Types of Dynamic Routing Protocols

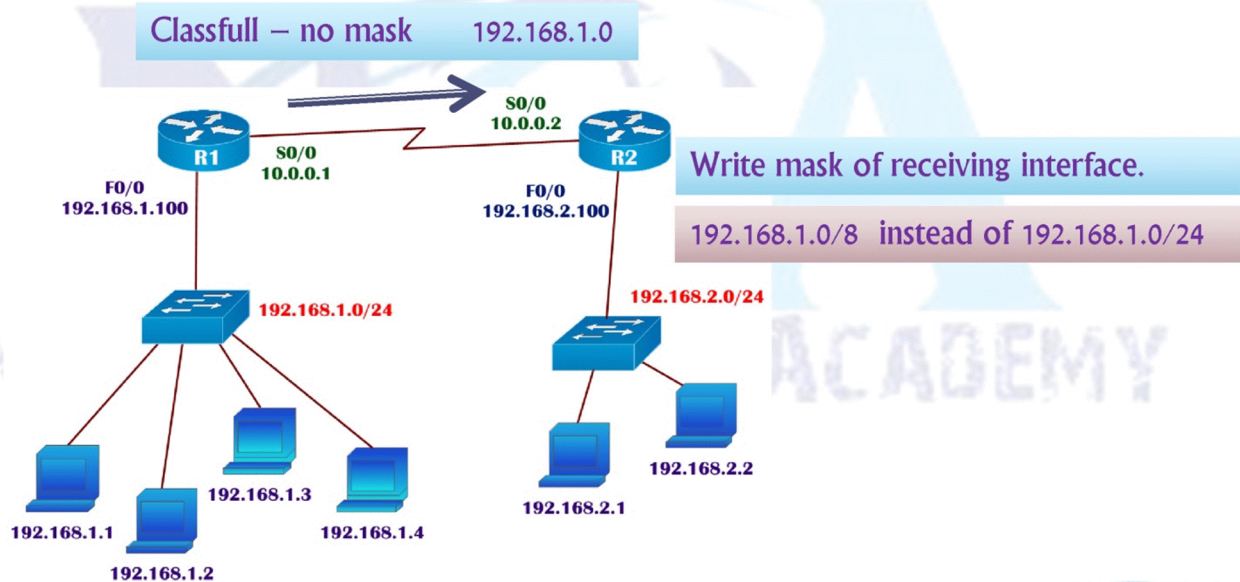
- Distance Vector Protocol
- Link State Protocol
- Hybrid Protocol

Types of Dynamic Routing Protocols

Distance Vector	Link State	Hybrid (Advance Distance vector)
Works with Bellman Ford algorithm	Works with Dijkstra algorithm	Works with DUAL algorithm
Periodic updates	Incremental updates Link state updates	Incremental updates
Full Routing tables are exchanged	Missing routes are exchanged	Missing routes are exchanged
Classful routing protocol	Classless routing protocol	Classless routing protocol
Updates are through broadcast	Updates are through multicast	Updates are through multicast
Example: RIP v1, RIPv2, IGRP	Example : OSPF, IS-IS	Example : EIGRP
Less overhead	More overhead	Less overhead
Easy to configure	Difficult to configure	Easy to configure

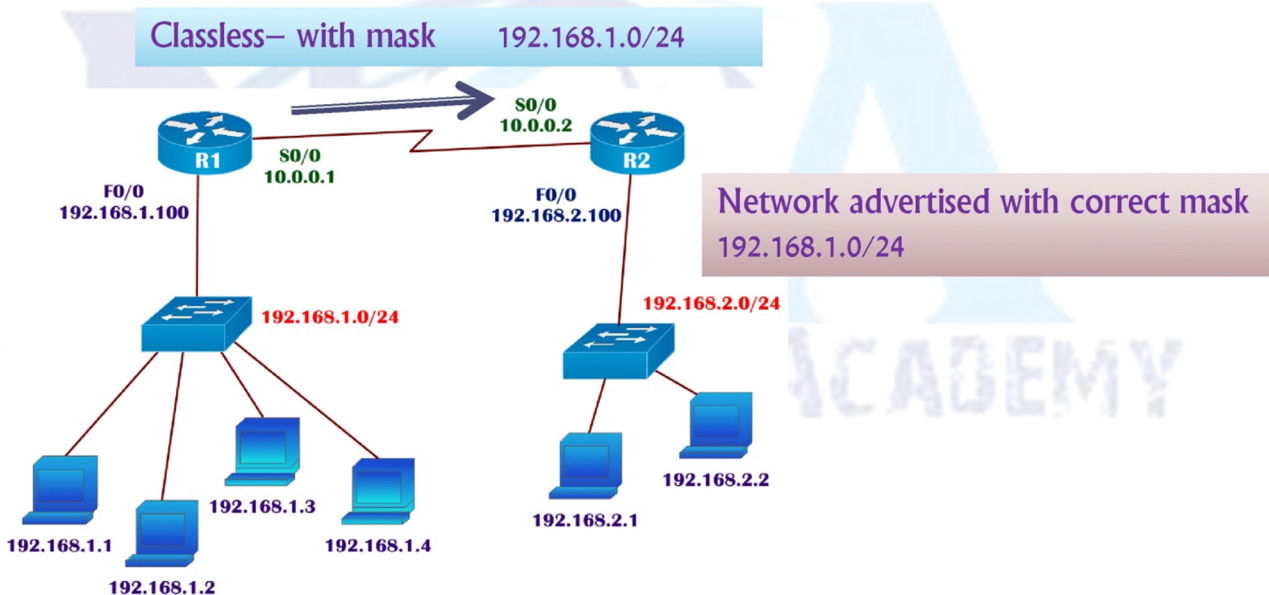
Classfull protocols

- ▶ Classful routing protocol do not carry the subnet mask information along with updates
- ▶ which means that all devices in the network must use the same subnet mask (FLSM or default same class)
 - Ex : RIPv1 , IGRP



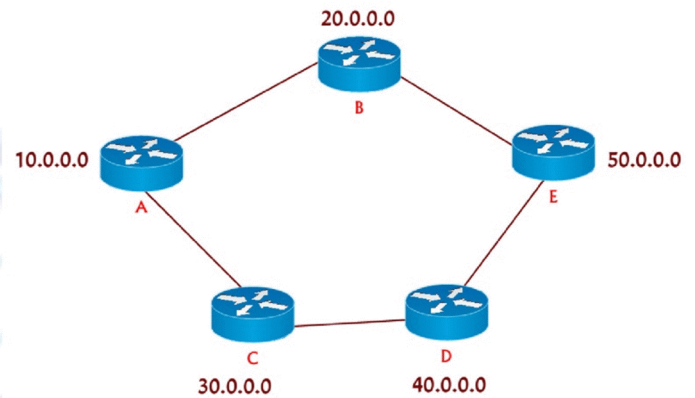
Classless protocols

- ▶ Classless routing protocol carry the subnet mask information along with updates
- ▶ That's why they support sub networks(VLSM and FLSM) and default networks also
 - Ex : RIPv2 , EIGRP , OSPF , IS-IS



Routing Information Protocol

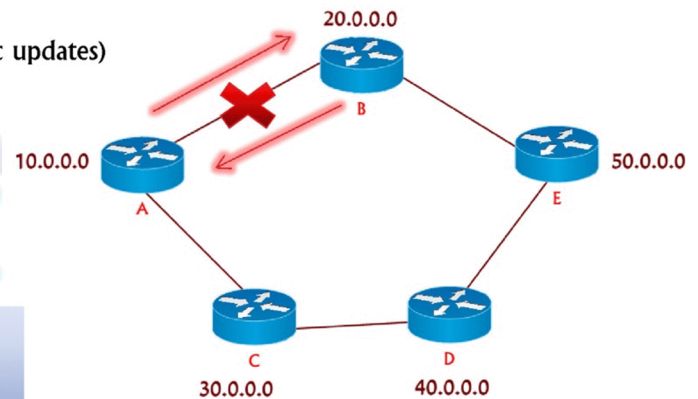
- Open Standard Protocol (Cisco/ non-cisco)
- Classfull routing protocol (not carry subnetmask)
- Updates are broadcasted via 255.255.255.255
- Metric : Hop count
- Load Balancing up to 4 equal paths
- Max Hop counts = 15 / Max routers = 16
- Applicable for small organizations
- Administrative distance is 120
- Exchange entire routing table for every 30 seconds. (periodic updates)



Rip Timers

Update Timer :

- Exchange entire routing table for every 30 seconds. (periodic updates)



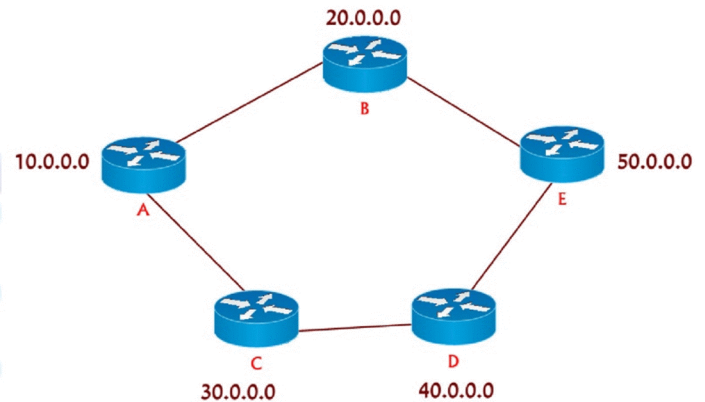
Update timer
30 sec

Hold down timer
180 sec

Invalid timer
180 sec (30+150)

Flush timer
240 sec (180+ 60)

Rip Timers



Update timer : 30 sec

- Time between consecutive updates

Invalid timer : 180 sec

- Time a router waits to hear updates
- The route is marked unreachable if there is no update during this interval.

Flush timer : 240 sec

- Time before the invalid route is removed from the routing table

Hold Down timer : 180 Sec

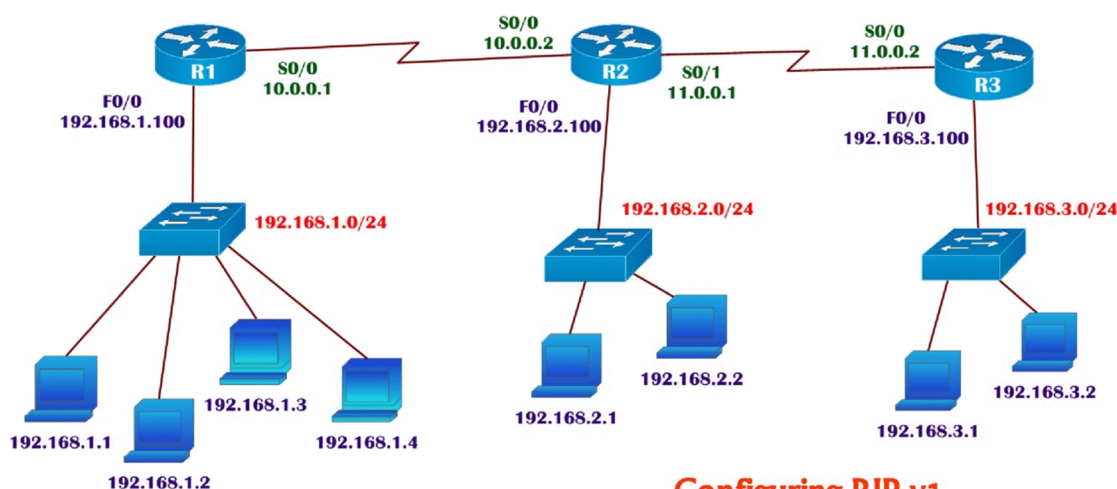
- Stabilizes routing information and helps preventing routing loops during periods when the topology is converging on new information.

RIPv1

- ▶ Classful routing protocol (not carry mask)
- ▶ Updates via broadcasts (255.255.255.255)
- ▶ No support for authentication.

RIPv2

- ▶ Classless routing protocol (carry mask)
- ▶ Updates via multicast address 224.0.0.9
- ▶ Supports authentication



Configuring RIP v1

```
Router(config)# router rip
```

```
Router(config-router)# network <Network ID>
```

Configuring RIP v2

```
Router(config)# router rip
```

```
Router(config-router)# network <Network ID>
```

```
Router(config-router)# version 2
```

LAB : Routing using RIPv2

```
R-1(config)#router rip
```

```
R-1(config-router)#network 192.168.1.0
```

```
R-1(config-router)#network 10.0.0.0
```

```
R-1(config-router)#version 2
```

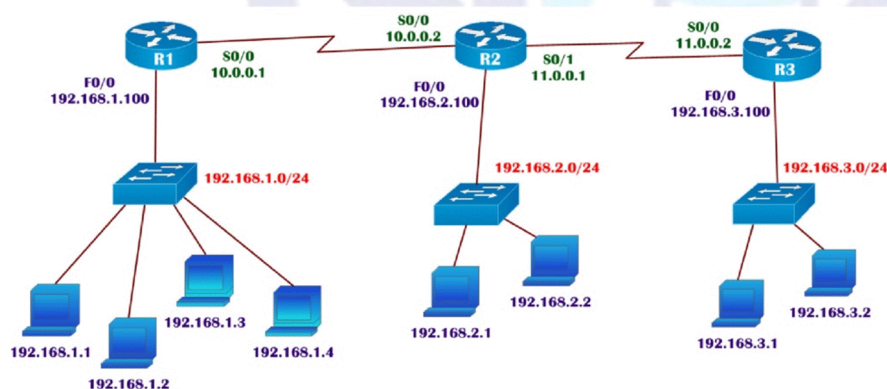
```
R-2(config)#router rip
```

```
R-2(config-router)#network 192.168.2.0
```

```
R-2(config-router)#network 10.0.0.0
```

```
R-2(config-router)#network 11.0.0.0
```

```
R-2(config-router)#version 2
```



```
R-3(config)#router rip
```

```
R-3(config-router)#network 192.168.3.0
```

```
R-3(config-router)#network 11.0.0.0
```

```
R-3(config-router)#version 2
```

RIPv2 Verification commands

R-1#sh ip route

Gateway of last resort is not set

```
C 10.0.0.0/8 is directly connected, Serial0/0
R 11.0.0.0/8 [120/1] via 10.0.0.2, 00:00:03, Serial0/0
C 192.168.1.0/24 is directly connected, FastEthernet0/0
R 192.168.2.0/24 [120/1] via 10.0.0.2, 00:00:03, Serial0/0
R 192.168.3.0/24 [120/2] via 10.0.0.2, 00:00:03, Serial0/0
```

PC>ping 192.168.3.1

Pinging 192.168.3.1 with 32 bytes of data:

Reply from 192.168.3.1: bytes=32 time=20ms TTL=126

Reply from 192.168.3.1: bytes=32 time=20ms TTL=126

Reply from 192.168.3.1: bytes=32 time=21ms TTL=126

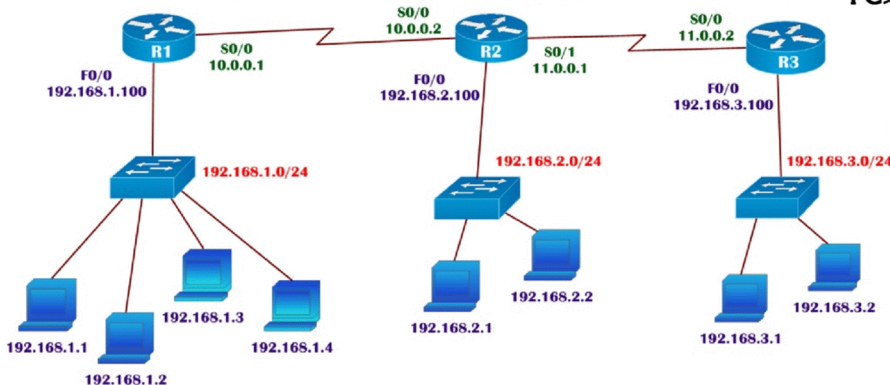
Reply from 192.168.3.1: bytes=32 time=21ms TTL=126

PC>tracert 192.168.3.1

Tracing route to 192.168.3.1 over a maximum of 30 hops:

1	5 ms	8 ms	8 ms	192.168.1.100
2	12 ms	9 ms	8 ms	10.0.0.2
3	17 ms	6 ms	12 ms	11.0.0.2
4	24 ms	27 ms	25 ms	192.168.3.1

Trace complete.

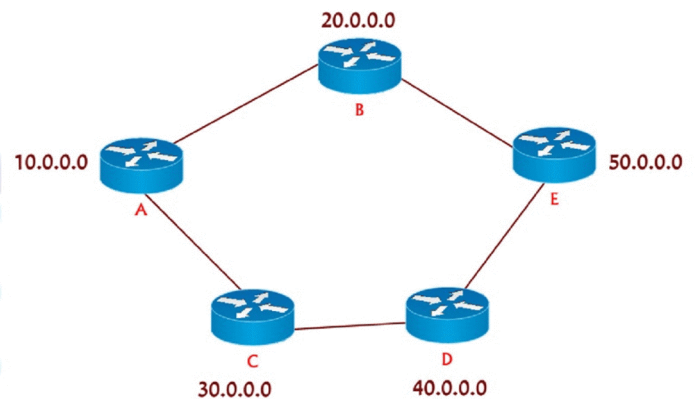


Advantages of RIP

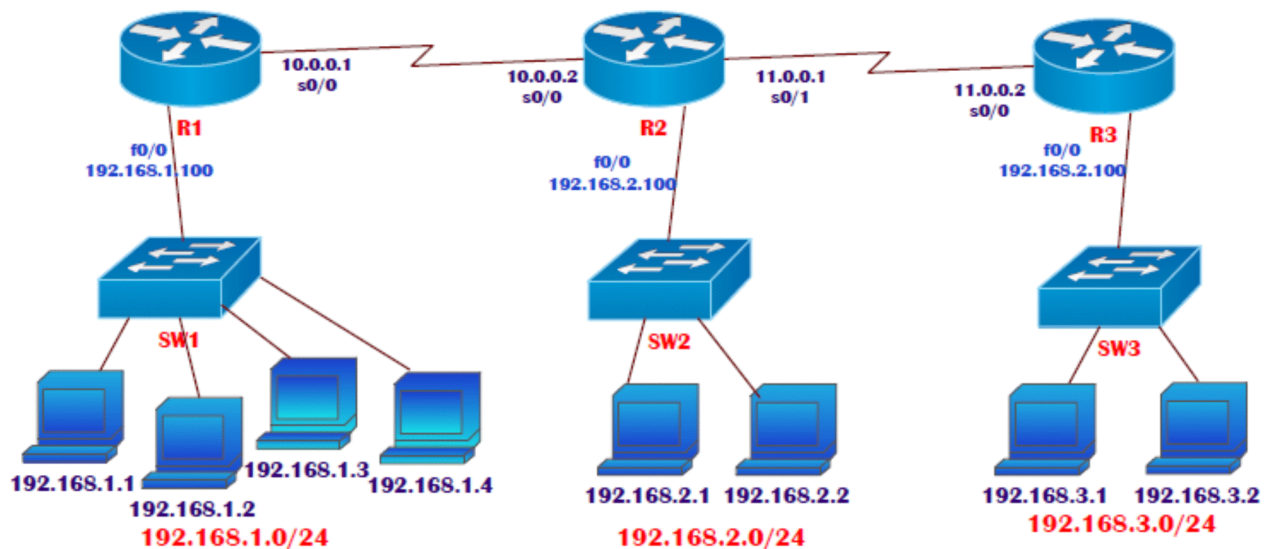
- Easy to configure
- No design constraints (unlike OSPF)
- Less overhead

Disadvantage of RIP

- Bandwidth utilization is very high as broadcast for every 30 seconds (periodic updates)
- Works only on hop count (not consider BW)
- Applicable for small organizations (maximum hop counts = 15)
- Slow convergence (240 sec)



LAB: DYNAMIC ROUTING USING RIPV2



STEPS:

Pre-requirement for LAB (check previous labs)

- 1) Design the topology (connectivity)
- 2) Assign the IP address according to diagram
- 3) Make sure that interfaces used should be in UP UP state

What we do in this lab

- 4) Dynamic routing using RIPv2
- 5) Verify Routing table and reachability between the LAN's (using PING and TRACE commands)

R-1#sh ip route

Gateway of last resort is not set

C 10.0.0.0/8 is directly connected, Serial0/0

C 192.168.1.0/24 is directly connected, FastEthernet0/0

R-2#sh ip route

Gateway of last resort is not set

C 10.0.0.0/8 is directly connected, Serial0/0

C 11.0.0.0/8 is directly connected, Serial0/1

C 192.168.2.0/24 is directly connected, FastEthernet0/0

R-3#sh ip route

Gateway of last resort is not set

C 11.0.0.0/8 is directly connected, Serial0/0

C 192.168.3.0/24 is directly connected, FastEthernet0/0

Router- 1

R-1(config)#router rip

R-1(config-router)#version 2


```
R-1(config-router)#network 192.168.1.0
```

```
R-1(config-router)#network 10.0.0.0
```

```
R-1(config-router)#end
```

Router – 2

```
R-2(config)#router rip
```

```
R-2(config-router)#version 2
```

```
R-2(config-router)#network 192.168.2.0
```

```
R-2(config-router)#network 10.0.0.0
```

```
R-2(config-router)#network 11.0.0.0
```

```
R-2(config-router)#end
```

Router – 3

```
R-3(config)#router rip
```

```
R-3(config-router)#version 2
```

```
R-3(config-router)#network 192.168.3.0
```

```
R-3(config-router)#network 11.0.0.0
```

```
R-3(config-router)#end
```

```
R-1#sh ip route
```

```
Gateway of last resort is not set
```

```
C 10.0.0.0/8 is directly connected, Serial0/0
```

```
R 11.0.0.0/8 [120/1] via 10.0.0.2, 00:00:03, Serial0/0
```

```
C 192.168.1.0/24 is directly connected, FastEthernet0/0
```

```
R 192.168.2.0/24 [120/1] via 10.0.0.2, 00:00:03, Serial0/0
```

```
R 192.168.3.0/24 [120/2] via 10.0.0.2, 00:00:03, Serial0/0
```

```
R-2#sh ip route
```

```
Gateway of last resort is not set
```

```
C 10.0.0.0/8 is directly connected, Serial0/0
```

```
C 11.0.0.0/8 is directly connected, Serial0/1
```

```
R 192.168.1.0/24 [120/1] via 10.0.0.1, 00:00:08, Serial0/0
```

```
C 192.168.2.0/24 is directly connected, FastEthernet0/0
```

```
R 192.168.3.0/24 [120/1] via 11.0.0.2, 00:00:16, Serial0/1
```

```
R-3#sh ip route
```

```
Gateway of last resort is not set
```

```
R 10.0.0.0/8 [120/1] via 11.0.0.1, 00:00:26, Serial0/0
```

```
C 11.0.0.0/8 is directly connected, Serial0/0
```

```
R 192.168.1.0/24 [120/2] via 11.0.0.1, 00:00:26, Serial0/0
```

```
R 192.168.2.0/24 [120/1] via 11.0.0.1, 00:00:26, Serial0/0
```

```
C 192.168.3.0/24 is directly connected, FastEthernet0/0
```

```
R-1#show ip protocols
```

```
Routing Protocol is "rip"
```

```
Sending updates every 30 seconds, next due in 8 seconds
```

Invalid after 180 seconds, hold down 180, flushed after 240

Outgoing update filter list for all interfaces is not set

Incoming update filter list for all interfaces is not set

Redistributing: rip

Default version control: send version 2, receive 2

Interface	Send	Recv	Triggered RIP	Key-chain
-----------	------	------	---------------	-----------

FastEthernet0/0	2	2		
-----------------	---	---	--	--

Serial0/0	2	2		
-----------	---	---	--	--

Automatic network summarization is in effect

Maximum path: 4

Routing for Networks:

10.0.0.0

192.168.1.0

Passive Interface(s):

Routing Information Sources:

Gateway	Distance	Last Update
10.0.0.2	120	00:00:02

Distance: (default is 120)

R-1#show ip route rip

R 11.0.0.0/8 [120/1] via 10.0.0.2, 00:00:24, Serial0/0

R 192.168.2.0/24 [120/1] via 10.0.0.2, 00:00:24, Serial0/0

R 192.168.3.0/24 [120/2] via 10.0.0.2, 00:00:24, Serial0/0

PC>ipconfig

IP Address.....: 192.168.1.1

Subnet Mask.....: 255.255.255.0

Default Gateway.....: 192.168.1.100

PC>ping 192.168.2.1

Pinging 192.168.2.1 with 32 bytes of data:

Request timed out.

Reply from 192.168.2.1: bytes=32 time=19ms TTL=126

Reply from 192.168.2.1: bytes=32 time=20ms TTL=126

Reply from 192.168.2.1: bytes=32 time=14ms TTL=126

PC>ping 192.168.3.1

Pinging 192.168.3.1 with 32 bytes of data:

Request timed out.

Reply from 192.168.3.1: bytes=32 time=27ms TTL=125

Reply from 192.168.3.1: bytes=32 time=22ms TTL=125

Reply from 192.168.3.1: bytes=32 time=25ms TTL=125

PC>tracert 192.168.3.1

Tracing route to 192.168.3.1 over a maximum of 30 hops:

1 5 ms 8 ms 8 ms 192.168.1.100

2 12 ms 9 ms 8 ms 10.0.0.2

3 17 ms 6 ms 12 ms 11.0.0.2

4 24 ms 27 ms 25 ms 192.168.3.1

Trace complete.

R-1#ping 192.168.3.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.3.1, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 9/16/31 ms

R-3#ping 192.168.1.1

Type escape sequence to abort.

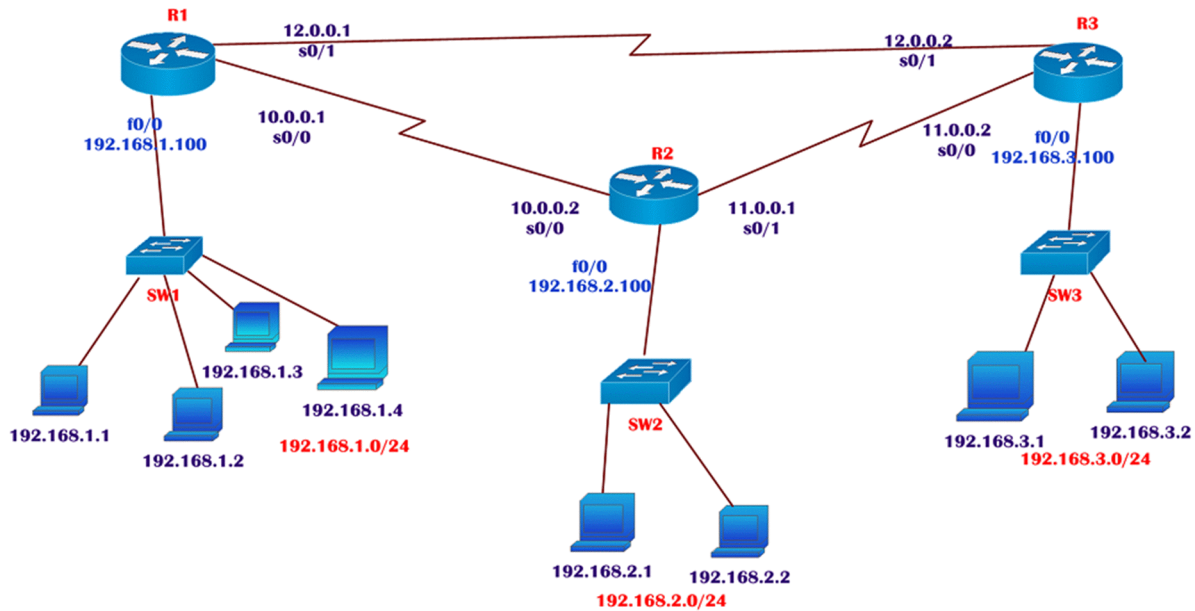
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 10/15/18 ms



LAB: RIPv2 – Redundant links



STEPS:

Pre-requirement for LAB (check previous labs)

- 1) Design the topology (connectivity)
- 2) Assign the IP address according to diagram
- 3) Make sure that interfaces used should be in UP UP state

What we do in this lab

- 4) Dynamic routing using RIPv2
- 5) Verify Routing table and reachability between the LAN's (using PING and TRACE commands)

R-1#sh ip int brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.1.100	YES	manual	up	up
Serial0/0	10.0.0.1	YES	manual	up	up
Serial0/1	12.0.0.1	YES	manual	up	up

R-1#sh ip route

```

Gateway of last resort is not set
C 10.0.0.0/8 is directly connected, Serial0/0
C 12.0.0.0/8 is directly connected, Serial0/1
C 192.168.1.0/24 is directly connected, FastEthernet0/0
  
```

R-1(config)#router rip

R-1(config-router)#version 2

R-1(config-router)#network 192.168.1.0

R-1(config-router)#network 10.0.0.0

R-1(config-router)#network 12.0.0.0

R-2#sh ip int brief

Interface	IP-Address	OK?	Method	Status	Protocol
-----------	------------	-----	--------	--------	----------

FastEthernet0/0	192.168.2.100	YES	manual	up	up
Serial0/0	10.0.0.2	YES	manual	up	up
Serial0/1	11.0.0.1	YES	manual	up	up

R-2#sh ip route

Gateway of last resort is not set
 C 10.0.0.0/8 is directly connected, Serial0/0
 C 11.0.0.0/8 is directly connected, Serial0/1
 C 192.168.2.0/24 is directly connected, FastEthernet0/0

R-2(config)#router rip

R-2(config-router)#version 2

R-2(config-router)#network 192.168.2.0

R-2(config-router)#network 10.0.0.0

R-2(config-router)#network 11.0.0.0

R-2(config-router)#end

R-3#sh ip int brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.3.100	YES	manual	up	up
Serial0/0	11.0.0.2	YES	manual	up	up
Serial0/1	12.0.0.2	YES	manual	up	up

R-3#sh ip route

Gateway of last resort is not set
 C 11.0.0.0/8 is directly connected, Serial0/0
 C 12.0.0.0/8 is directly connected, Serial0/1
 C 192.168.3.0/24 is directly connected, FastEthernet0/0

R-3(config)#router rip

R-3(config-router)#version 2

R-3(config-router)#net 192.168.3.0

R-3(config-router)#network 11.0.0.0

R-3(config-router)#network 12.0.0.0

R-3(config-router)#end

R-3#sh ip route

Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
 D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
 N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
 E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
 i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
 * - candidate default, U - per-user static route, o - ODR
 P - periodic downloaded static route

Gateway of last resort is not set

R 10.0.0.0/8 [120/1] via 11.0.0.1, 00:00:11, Serial0/0
 [120/1] via 12.0.0.1, 00:00:19, Serial0/1
 C 11.0.0.0/8 is directly connected, Serial0/0
 C 12.0.0.0/8 is directly connected, Serial0/1
 R 192.168.1.0/24 [120/1] via 12.0.0.1, 00:00:19, Serial0/1

R 192.168.2.0/24 [120/1] via 11.0.0.1, 00:00:11, Serial0/0

C 192.168.3.0/24 is directly connected, FastEthernet0/0

R-3#sh ip route rip

R 10.0.0.0/8 [120/1] via 11.0.0.1, 00:00:15, Serial0/0
[120/1] via 12.0.0.1, 00:00:20, Serial0/1

R 192.168.1.0/24 [120/1] via 12.0.0.1, 00:00:20, Serial0/1

R 192.168.2.0/24 [120/1] via 11.0.0.1, 00:00:15, Serial0/0

R-3#sh ip protocols

Routing Protocol is "rip"

Sending updates every 30 seconds, next due in 25 seconds

Invalid after 180 seconds, hold down 180, flushed after 240

Outgoing update filter list for all interfaces is not set

Incoming update filter list for all interfaces is not set

Redistributing: rip

Default version control: send version 2, receive 2

Interface	Send	Recv	Triggered	RIP	Key-chain
FastEthernet0/0	2	2			
Serial0/0	2	2			
Serial0/1	2	2			

Automatic network summarization is in effect

Maximum path: 4

Routing for Networks:

11.0.0.0

12.0.0.0

192.168.3.0

Passive Interface(s):

Routing Information Sources:

Gateway	Distance	Last Update
11.0.0.1	120	00:00:07
12.0.0.1	120	00:00:09

Distance: (default is 120)

R-1#sh ip route rip

R 11.0.0.0/8 [120/1] via 10.0.0.2, 00:00:17, Serial0/0
[120/1] via 12.0.0.2, 00:00:06, Serial0/1

R 192.168.2.0/24 [120/1] via 10.0.0.2, 00:00:17, Serial0/0

R 192.168.3.0/24 [120/1] via 12.0.0.2, 00:00:06, Serial0/1

PC>ipconfig

FastEthernet0 Connection:(default port)

Link-local IPv6 Address.....: FE80::201:97FF:FEC6:DEEA

IP Address.....: 192.168.1.1

Subnet Mask.....: 255.255.255.0

Default Gateway.....: 192.168.1.100

PC>ping 192.168.2.1

Pinging 192.168.2.1 with 32 bytes of data:

Request timed out.
Reply from 192.168.2.1: bytes=32 time=4ms TTL=126
Reply from 192.168.2.1: bytes=32 time=1ms TTL=126
Reply from 192.168.2.1: bytes=32 time=1ms TTL=126

PC>tracert 192.168.2.1

Tracing route to 192.168.2.1 over a maximum of 30 hops:

1	0 ms	0 ms	0 ms	192.168.1.100
2	0 ms	1 ms	0 ms	10.0.0.2
3	16 ms	0 ms	1 ms	192.168.2.1

Trace complete.

PC>ping 192.168.3.1

Pinging 192.168.3.1 with 32 bytes of data:

Request timed out.
Reply from 192.168.3.1: bytes=32 time=11ms TTL=126
Reply from 192.168.3.1: bytes=32 time=4ms TTL=126
Reply from 192.168.3.1: bytes=32 time=11ms TTL=126

PC>tracert 192.168.3.1

Tracing route to 192.168.3.1 over a maximum of 30 hops:

1	1 ms	0 ms	0 ms	192.168.1.100
2	1 ms	0 ms	4 ms	12.0.0.2
3	1 ms	1 ms	0 ms	192.168.3.1

Trace complete.

R-1(config)#interface serial 0/0

R-1(config-if)#shutdown

R-1(config-if)#end

R-1#sh ip route rip

R 11.0.0.0/8 [120/1] via 12.0.0.2, 00:00:22, Serial0/1
R 192.168.2.0/24 [120/2] via 12.0.0.2, 00:00:22, Serial0/1
R 192.168.3.0/24 [120/1] via 12.0.0.2, 00:00:22, Serial0/1

PC>ping 192.168.2.1

Pinging 192.168.2.1 with 32 bytes of data:

Reply from 192.168.2.1: bytes=32 time=11ms TTL=125
Reply from 192.168.2.1: bytes=32 time=12ms TTL=125
Reply from 192.168.2.1: bytes=32 time=8ms TTL=125
Reply from 192.168.2.1: bytes=32 time=13ms TTL=125

PC>tracert 192.168.2.1

Tracing route to 192.168.2.1 over a maximum of 30 hops:

```
1 1 ms    0 ms    0 ms    192.168.1.100
2 1 ms    0 ms    0 ms    12.0.0.2
3 2 ms    2 ms    0 ms    11.0.0.1
4 13 ms   19 ms   12 ms   192.168.2.1
Trace complete.
```

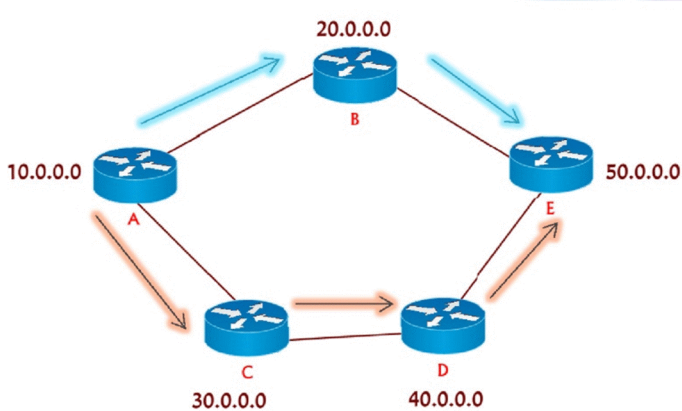
```
R-1(config)#interface serial 0/0
R-1(config-if)#no shutdown
R-1(config)#end
```

```
R-1#sh ip route rip
R   11.0.0.0/8 [120/1] via 12.0.0.2, 00:00:03, Serial0/1
    [120/1] via 10.0.0.2, 00:00:12, Serial0/0
R   192.168.2.0/24 [120/1] via 10.0.0.2, 00:00:12, Serial0/0
R   192.168.3.0/24 [120/1] via 12.0.0.2, 00:00:03, Serial0/1
```



Administrative Distance

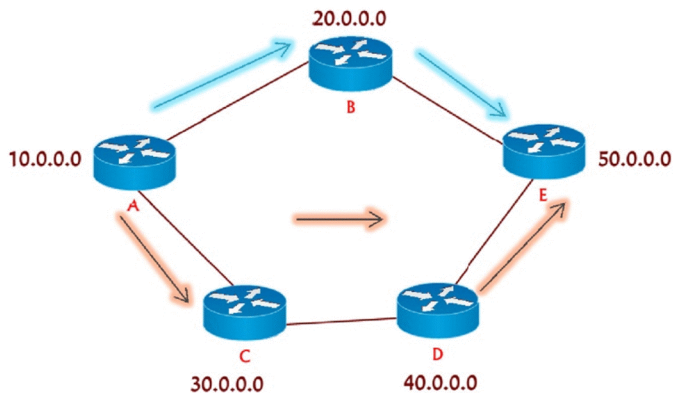
Trust worthiness of the information received by the router.



Best route is decided based on
type of routing static/ RIP/ EIGRP/OSPF

Administrative Distance

- ▶ Trust worthiness of the information received by the router.
- ▶ The Number is between 0 and 255
- ▶ Less value is more preferred routing



Default administrative distances

Directly Connected = 0

Static Route = 1

IGRP = 100

EIGRP = 90

OSPF = 110

RIP = 120

Static Routing uses manual path given by admin

RIP uses hop counts (less better)

ABE - 2

ACDE - 3

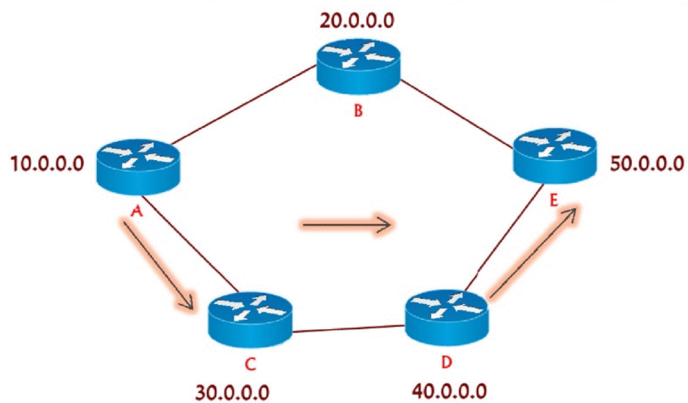
EIGRP considers bandwidth (more better)

ABE - 2 Mbps

ACDE - 4 Mbps

Administrative Distance

Less AD value is more preferred routing



Default administrative distances

Directly Connected = 0

Static Route = 1

IGRP = 100

EIGRP = 90

OSPF = 110

RIP = 120

Static Routing uses manual path given by admin

RIP uses hop counts (less better)

ABE - 2

ACDE - 3

EIGRP considers bandwidth (more better)

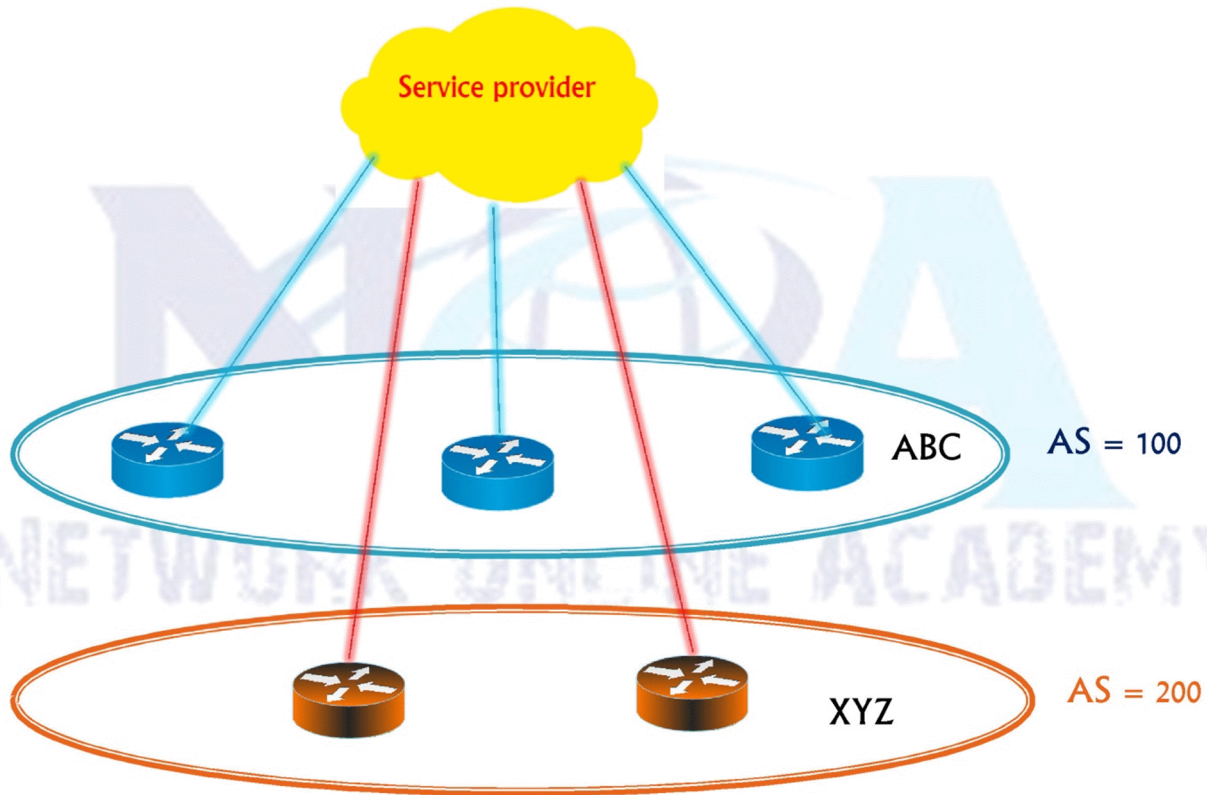
ABE - 2 Mbps

ACDE - 4 Mbps

Autonomous System Number

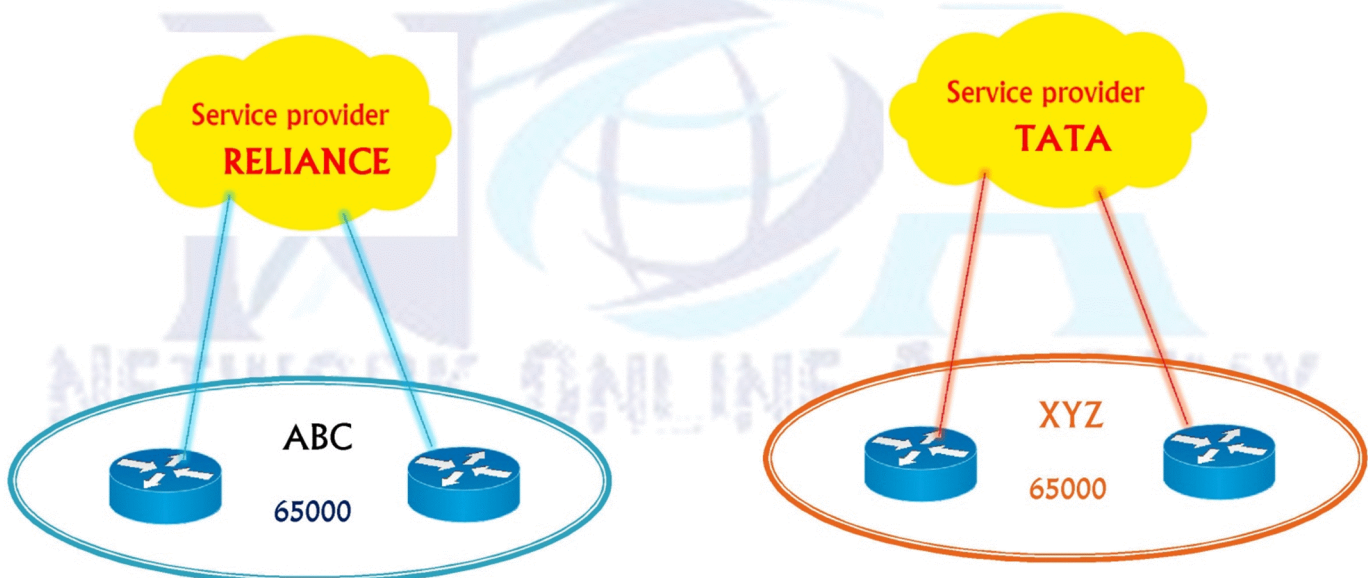
- is a collection of networks under a common administrative domain.
- A unique number identifying the Routing domain of the routers (one organization).
- Ranges from 1- 65535
 - Public AS (in between multiple SP) 1 – 64512
 - Private AS (same SP) 64513 – 65535

Autonomous System Number



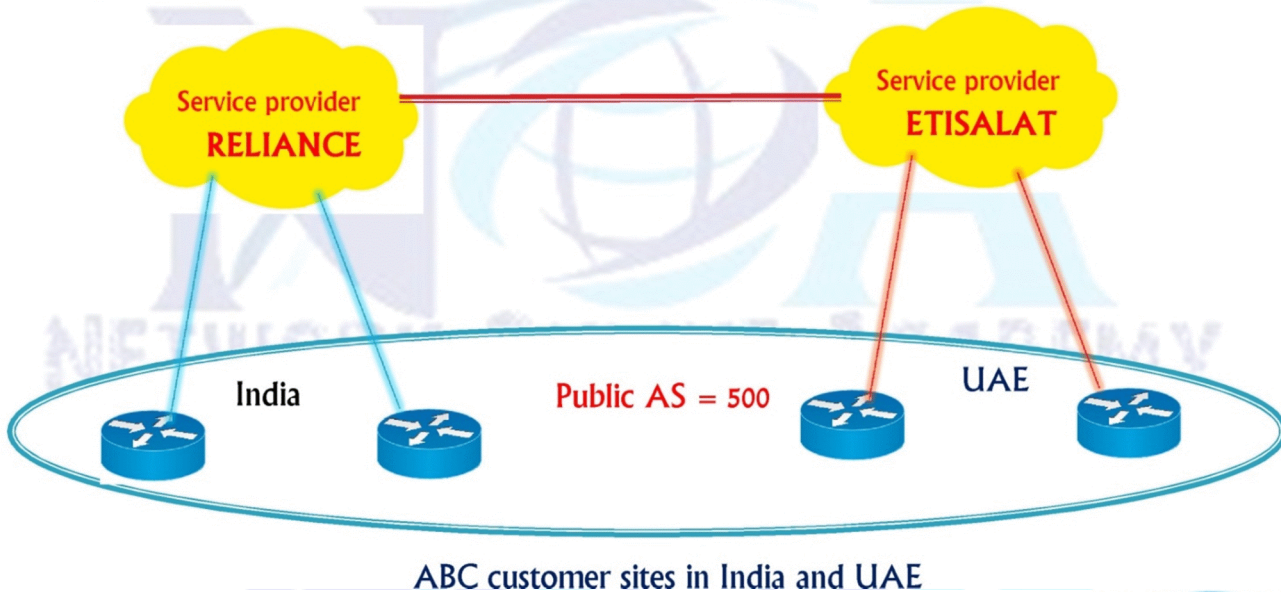
Private AS example

- Used with in the same service provider.
- unique with in service provider.
- Range = 64513 – 65535



Public AS example

- Used with in between multiple service provider.
- Globally unique.
- Range = 1 - 64512



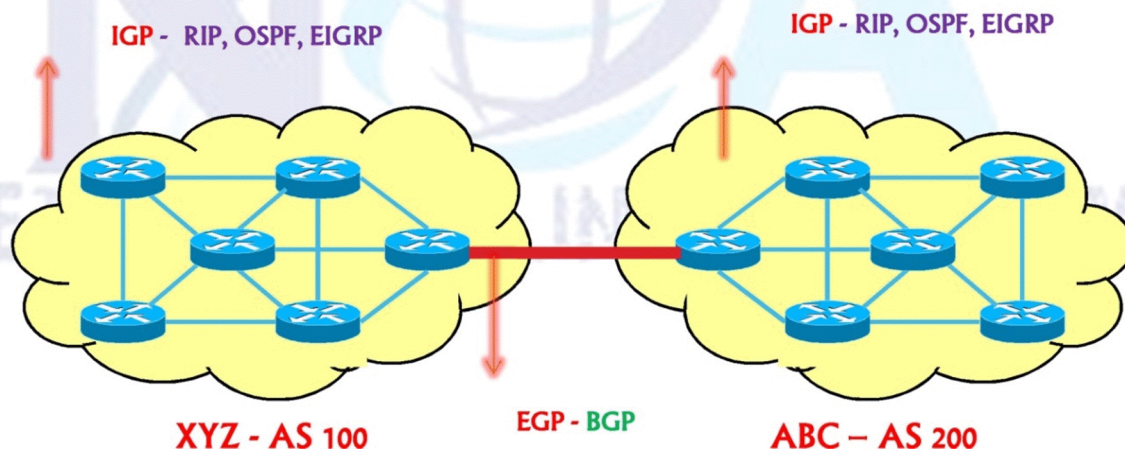
Routing Protocol Classification

IGP

- Interior Gateway Protocol
- used to communicate within same autonomous system
- RIP, IGRP, EIGRP, OSPF, IS-IS

EGP

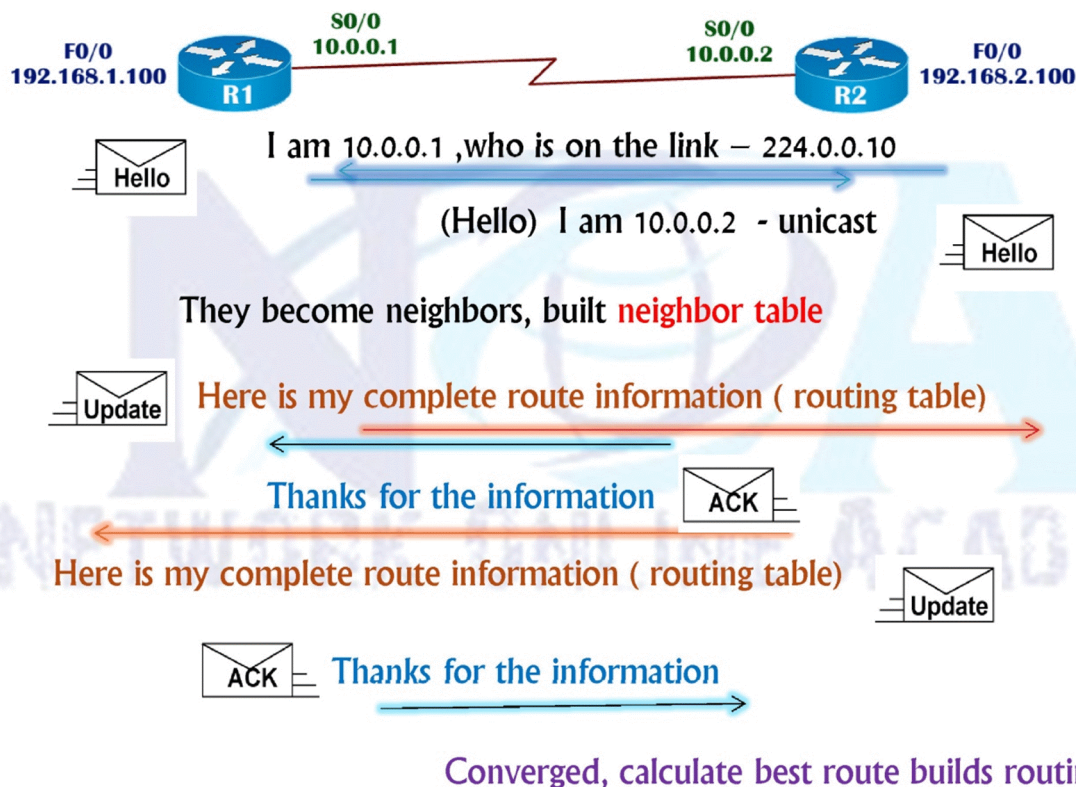
1. Exterior Gateway Protocol
2. used to communicate between two or more autonomous system
3. Border Gateway Protocol (BGP)



Enhanced Interior Gateway Routing Protocol

- ▶ Advanced distance vector (Hybrid protocol)
- ▶ Standard protocol (initially was cisco proprietary)
- ▶ Classless routing protocol (carry subnet-mask , support subnets/VLSM)
- ▶ Max Hop count is 255 (100 by default)
- ▶ Administrative distance is 90
- ▶ Easy and Flexible network design. (unlike OSPF)
- ▶ Uses Multicast (224.0.0.10) and unicast for initial neighbor discovery process

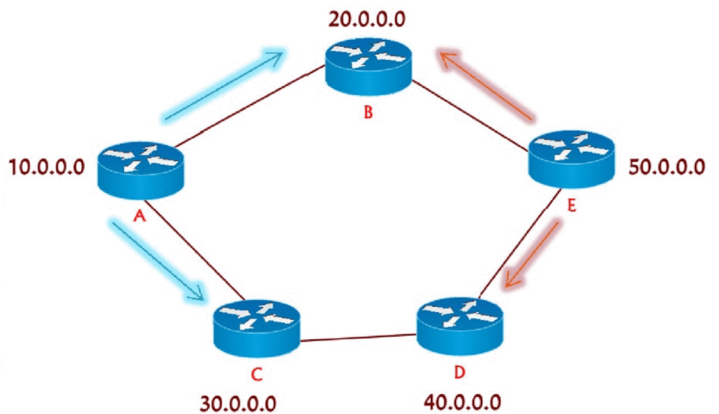
EIGRP step by step initial process



EIGRP Tables

Neighbor table

- Contains list of directly connected routers
- # **show ip eigrp neighbor**



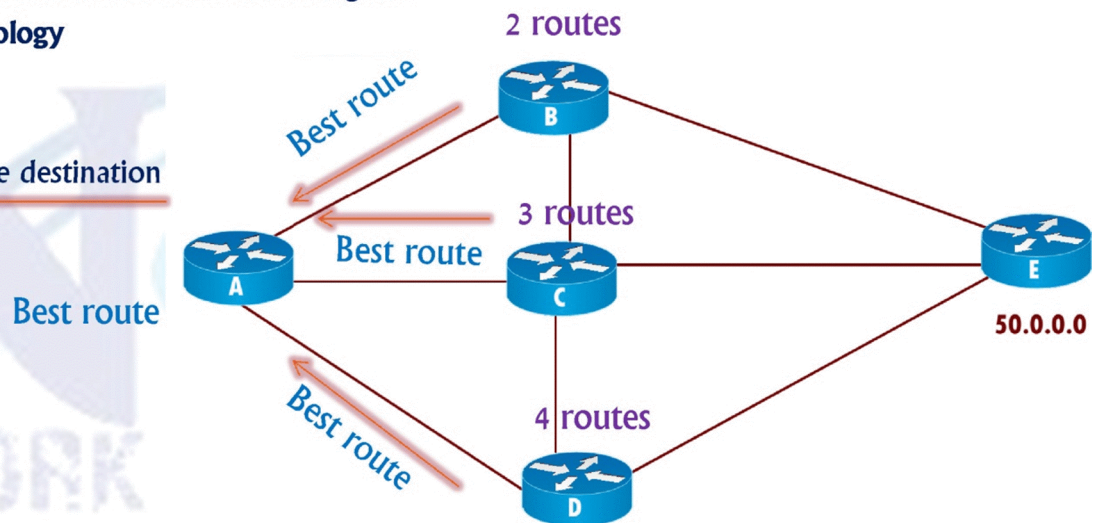
EIGRP Tables

Topology table

- List of all the best routes learned from each neighbor
- # **Show ip eigrp topology**

Routing table

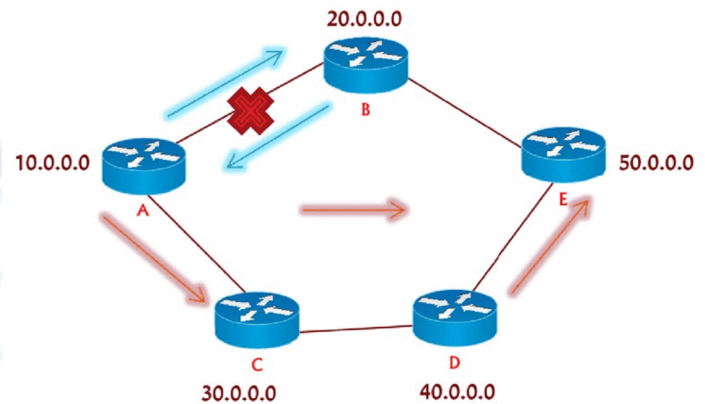
- The best route to the destination
- # **show ip route**



3 best routes from all 3 neighbors (stores in topology table)

Select the best route - (routing table) and advertise best route to neighbor

EIGRP Convergence



- ▶ Incremental updates
- ▶ Periodically send hello packets are sent every 5 seconds (dead – 15 sec)
- ▶ Convergence rate is fast (15 sec)

Also pre-calculates second best route

- best route = successor
- Second best route = feasible successor

EIGRP Metric – parameters



	Bandwidth	Delay	load	Reliability	MTU
Serial	1544 Kbps	20,000 Us	1 – 255	1 – 255	1500 bytes
Ethernet	10 Mbps	200 Us	1- less	1- less	
Fasteth	100 Mbps	100 Us	255 more	255 more	
gigeth	1000 Mbps	10 Us			

```
R-1(config)#interface serial 0/0
R-1(config-if)#bandwidth 1000
```

R-1#sh interfaces s0/0

```
Serial0/0 is up, line protocol is up (connected)
Hardware is HD64570
Internet address is 10.0.0.1/8
MTU 1500 bytes, BW 1000 Kbit, DLY 20000 usec,
reliability 255/255, txload 1/255, rxload 1/255
```



R-1#sh interfaces s0/0

```
Serial0/0 is up, line protocol is up (connected)
Hardware is HD64570
Internet address is 10.0.0.1/8
MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
reliability 255/255, txload 1/255, rxload 1/255
```


EIGRP Metric Calculation

BW Delay load Reliability MTU
K1 = 1 K3 = 1 K2 = 0 K4 = 0 K5 = 0

The EIGRP metric calculation formula is as below:

$$\text{metric} = \left[\left(K1 \times \frac{10^7}{BW_{\min}} + \frac{K2 \times BW_{\min}}{256 - \text{load}} + K3 \times \sum \text{delays} \right) \times \frac{K5}{K4 + \text{reliability}} \right] \times 256$$

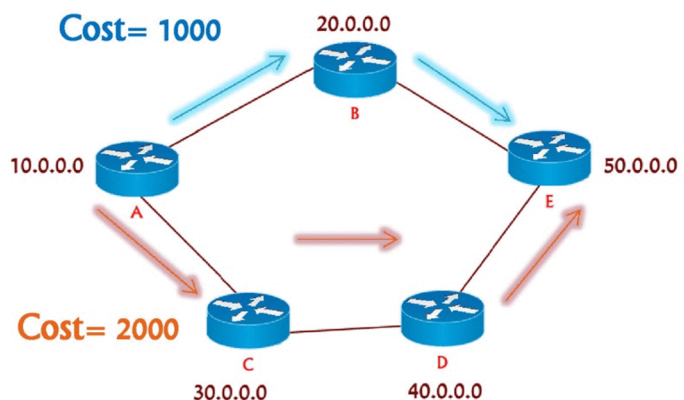
By default uses BW and Delay in the metric calculation.

Formula with default K values (K1 = 1, K2 = 0, K3 = 1, K4 = 0, K5 = 0):

$$\text{Metric} = [K1 * BW + ((K2 * BW) / (256 - \text{load})) + K3 * \text{delay}]$$

EIGRP cost

Least cost = best route



R-1#show ip route

Gateway of last resort is not set

C 10.0.0.0/8 is directly connected, Serial0/0

D 11.0.0.0/8 [90/2681856] via 10.0.0.2, 00:05:45, Serial0/0

C 192.168.1.0/24 is directly connected, FastEthernet0/0

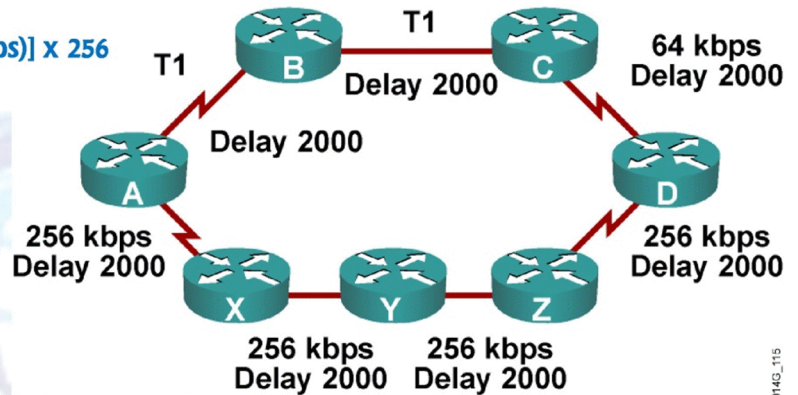
D 192.168.2.0/24 [90/2172416] via 10.0.0.2, 00:05:48, Serial0/0

D 192.168.3.0/24 [90/2684416] via 10.0.0.2, 00:02:49, Serial0/0

EIGRP Metric Calculation Example

Over all Delay = [sum of delays] x 256

Over all Bandwidth = $[10^7 / (\text{Min bandwidth in kbps})] \times 256$



A → B → C → D

Least bandwidth 64 kbps

Total delay 6,000

A → X → Y → Z → D

Least bandwidth 256 kbps

Total delay 8,000

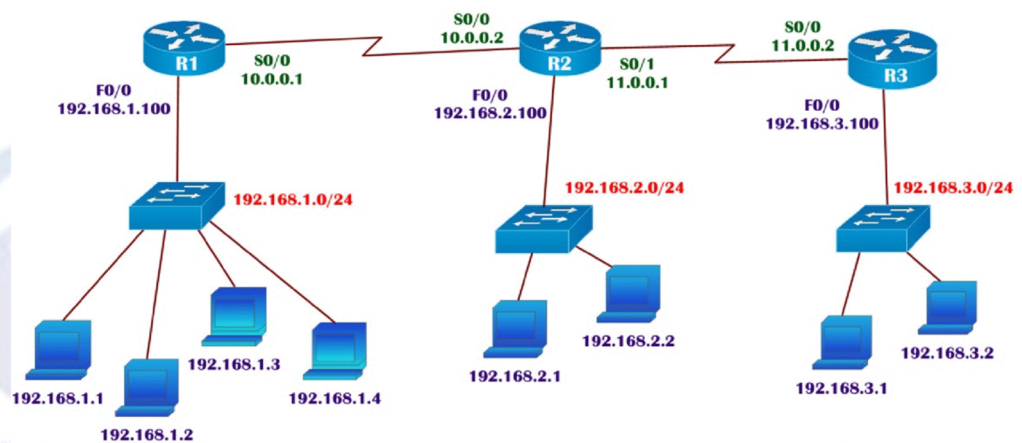
The EIGRP metric calculation formula is as below:

$$\text{metric} = \left[\left(K1 \times \frac{10^7}{BW_{\min}} + \frac{K2 \times BW_{\min}}{256 - \text{load}} + K3 \times \sum \text{delays} \right) \times \frac{K5}{K4 + \text{reliability}} \right] \times 256$$

EIGRP Configuration

Router(config)# **router eigrp** <AS NO>

Router(config-router)# **network** <Network ID>



R-1(config)# **router eigrp** 100

R-1(config-router)# **network** 192.168.1.0

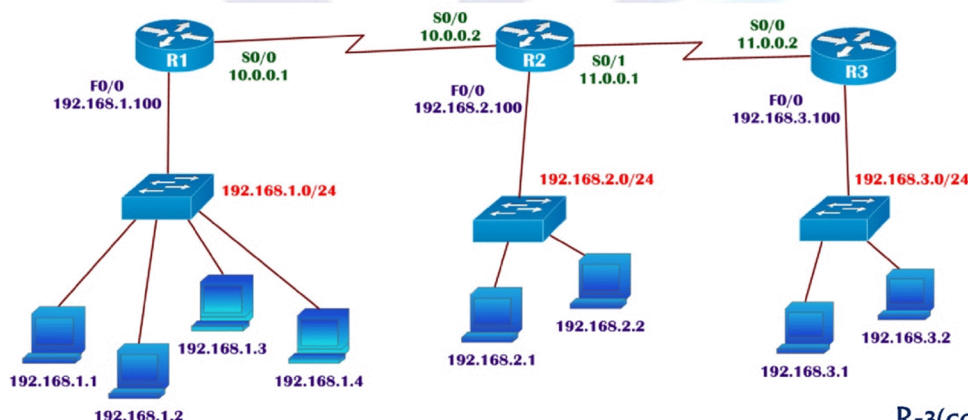
R-1(config-router)# **network** 10.0.0.0

EIGRP AS number has to match on all routers to establish neighbors and exchange routes

EIGRP Configuration

```
R-1(config)# router eigrp 100
R-1(config-router)# network 192.168.1.0
R-1(config-router)# network 10.0.0.0
```

```
R-2(config)#router eigrp 100
R-2(config-router)# network 192.168.2.0
R-2(config-router)# network 11.0.0.0
R-2(config-router)# network 10.0.0.0
```

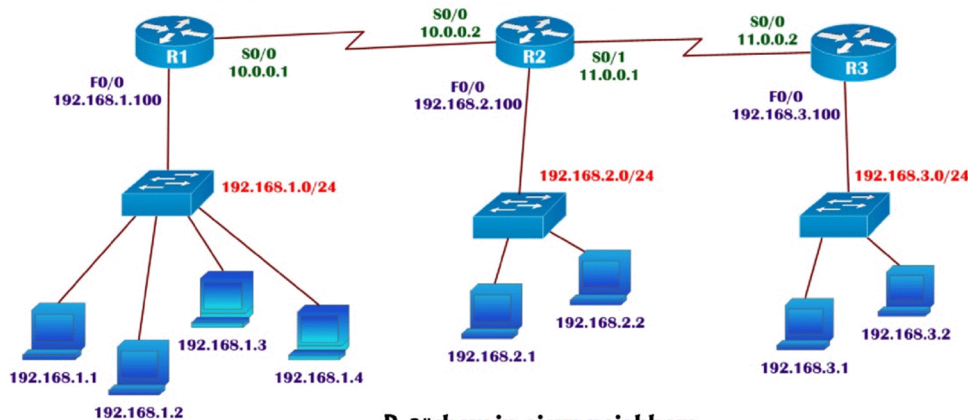


```
R-3(config)# router eigrp 100
R-3(config-router)# network 192.168.3.0
R-3(config-router)# network 11.0.0.0
```

EIGRP verification

R-1#show ip route

```
Gateway of last resort is not set
C    10.0.0.0/8 is directly connected, Serial0/0
D    11.0.0.0/8 [90/2681856] via 10.0.0.2, 00:05:45, Serial0/0
C    192.168.1.0/24 is directly connected, FastEthernet0/0
D    192.168.2.0/24 [90/2172416] via 10.0.0.2, 00:05:48, Serial0/0
D    192.168.3.0/24 [90/2684416] via 10.0.0.2, 00:02:49, Serial0/0
```

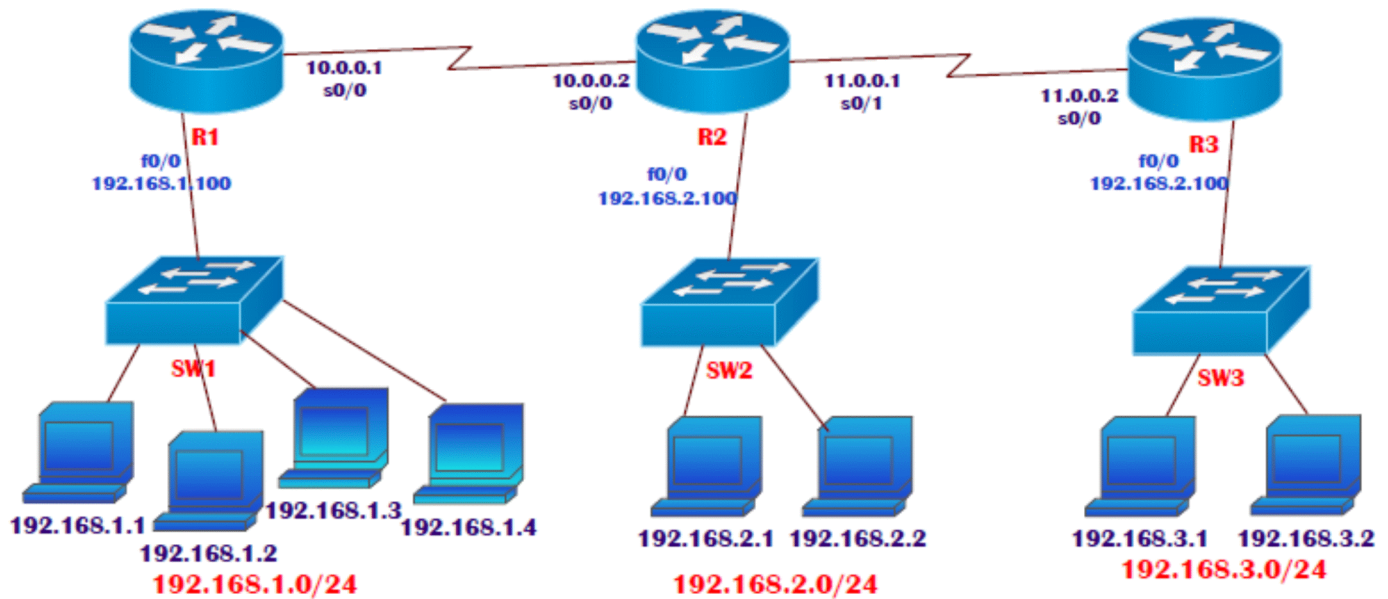


R-2#show ip eigrp neighbors

IP-EIGRP neighbors for process 100

H	Address	Interface	Hold (sec)	Uptime	SRTT (ms)	RTO	Q Cnt	Seq Num
0	10.0.0.1	Se0/0	10	00:03:44	40	1000	0	8
1	11.0.0.2	Se0/1	12	00:01:10	40	1000	0	7

LAB: DYNAMIC ROUTING USING EIGRP



_Pre-requirement for LAB (check previous labs)

- Design the topology (connectivity)
- Assign the IP address according to diagram
- Make sure that interfaces used should be in UP UP state

TASK

- Configure Dynamic routing using EIGRP 100
- Verify Routing table and reachability between the LAN's (using PING and TRACE commands)

R-1#sh ip route

Gateway of last resort is not set

C 10.0.0.0/8 is directly connected, Serial0/0

C 192.168.1.0/24 is directly connected, FastEthernet0/0

R-2#sh ip route

Gateway of last resort is not set

C 10.0.0.0/8 is directly connected, Serial0/0

C 11.0.0.0/8 is directly connected, Serial0/1

C 192.168.2.0/24 is directly connected, FastEthernet0/0

R-3#sh ip route

Gateway of last resort is not set

C 11.0.0.0/8 is directly connected, Serial0/0

C 192.168.3.0/24 is directly connected, FastEthernet0/0

ROUTER- 1

R-1(config)# router eigrp 100

R-1(config-router)# network 192.168.1.0

R-1(config-router)# network 10.0.0.0

ROUTER – 2

```
R-2(config)#router eigrp 100
R-2(config-router)# network 192.168.2.0
R-2(config-router)# network 11.0.0.0
R-2(config-router)# network 10.0.0.0
```

%DUAL-5-NBRCHANGE: IP-EIGRP 100: Neighbor 10.0.0.1 (Serial0/0) is up: new adjacency

ROUTER – 3

```
R-3(config)# router eigrp 100
R-3(config-router)# network 192.168.3.0
R-3(config-router)# network 11.0.0.0
```

%DUAL-5-NBRCHANGE: IP-EIGRP 100: Neighbor 11.0.0.1 (Serial0/0) is up: new adjacency

R-2#show ip eigrp neighbors

IP-EIGRP neighbors for process 100

H	Address	Interface	Hold (sec)	Uptime (ms)	SRTT Cnt	RTO Num	Q	Seq
0	10.0.0.1	Se0/0	10	00:03:44	40	1000	0	8
1	11.0.0.2	Se0/1	12	00:01:10	40	1000	0	7

R-1#show ip route

Gateway of last resort is not set

C 10.0.0.0/8 is directly connected, Serial0/0

D 11.0.0.0/8 [90/2681856] via 10.0.0.2, 00:05:45, Serial0/0

C 192.168.1.0/24 is directly connected, FastEthernet0/0

D 192.168.2.0/24 [90/2172416] via 10.0.0.2, 00:05:48, Serial0/0

D 192.168.3.0/24 [90/2684416] via 10.0.0.2, 00:02:49, Serial0/0

R-1#show ip route eigrp

D 11.0.0.0/8 [90/2681856] via 10.0.0.2, 00:06:05, Serial0/0

D 192.168.2.0/24 [90/2172416] via 10.0.0.2, 00:06:08, Serial0/0

D 192.168.3.0/24 [90/2684416] via 10.0.0.2, 00:03:09, Serial0/0

R-2#show ip route eigrp

D 192.168.1.0/24 [90/2172416] via 10.0.0.1, 00:07:26, Serial0/0

D 192.168.3.0/24 [90/2172416] via 11.0.0.2, 00:04:52, Serial0/1

R-3#sh ip route eigrp

D 10.0.0.0/8 [90/2681856] via 11.0.0.1, 00:04:32, Serial0/0

D 192.168.1.0/24 [90/2684416] via 11.0.0.1, 00:04:32, Serial0/0

D 192.168.2.0/24 [90/2172416] via 11.0.0.1, 00:04:32, Serial0/0

R-1#sh ip protocols

Routing Protocol is "eigrp 100"
 Outgoing update filter list for all interfaces is not set
 Incoming update filter list for all interfaces is not set
 Default networks flagged in outgoing updates
 Default networks accepted from incoming updates
 EIGRP metric weight K1=1, K2=0, K3=1, K4=0, K5=0
 EIGRP maximum hopcount 100
 EIGRP maximum metric variance 1
 Redistributing: eigrp 100
 Automatic network summarization is in effect
 Automatic address summarization:
 Maximum path: 4
 Routing for Networks:
 192.168.1.0
 10.0.0.0
 Routing Information Sources:
 Gateway Distance Last Update
 10.0.0.2 90 18606786
 Distance: internal 90 external 170

R-1#sh ip eigrp topology

IP-EIGRP Topology Table for AS 100

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
 r - Reply status

P 192.168.1.0/24, 1 successors, FD is 28160
 via Connected, FastEthernet0/0
 P 10.0.0.0/8, 1 successors, FD is 2169856
 via Connected, Serial0/0
 P 192.168.2.0/24, 1 successors, FD is 2172416
 via 10.0.0.2 (2172416/28160), Serial0/0
 P 11.0.0.0/8, 1 successors, FD is 2681856
 via 10.0.0.2 (2681856/2169856), Serial0/0
 P 192.168.3.0/24, 1 successors, FD is 2684416
 via 10.0.0.2 (2684416/2172416), Serial0/0

PC>ipconfig

IP Address.....: 192.168.1.1
 Subnet Mask.....: 255.255.255.0
 Default Gateway.....: 192.168.1.100

PC>ping 192.168.2.1

Pinging 192.168.2.1 with 32 bytes of data:
 Request timed out.
 Reply from 192.168.2.1: bytes=32 time=19ms TTL=126
 Reply from 192.168.2.1: bytes=32 time=20ms TTL=126
 Reply from 192.168.2.1: bytes=32 time=14ms TTL=126

PC>ping 192.168.3.1

Pinging 192.168.3.1 with 32 bytes of data:

Request timed out.

Reply from 192.168.3.1: bytes=32 time=27ms TTL=125

Reply from 192.168.3.1: bytes=32 time=22ms TTL=125

Reply from 192.168.3.1: bytes=32 time=25ms TTL=125

PC>tracert 192.168.3.1

Tracing route to 192.168.3.1 over a maximum of 30 hops:

1	5 ms	8 ms	8 ms	192.168.1.100
2	12 ms	9 ms	8 ms	10.0.0.2
3	17 ms	6 ms	12 ms	11.0.0.2
4	24 ms	27 ms	25 ms	192.168.3.1

Trace complete.

R-1#ping 192.168.3.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.3.1, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 9/16/31 ms

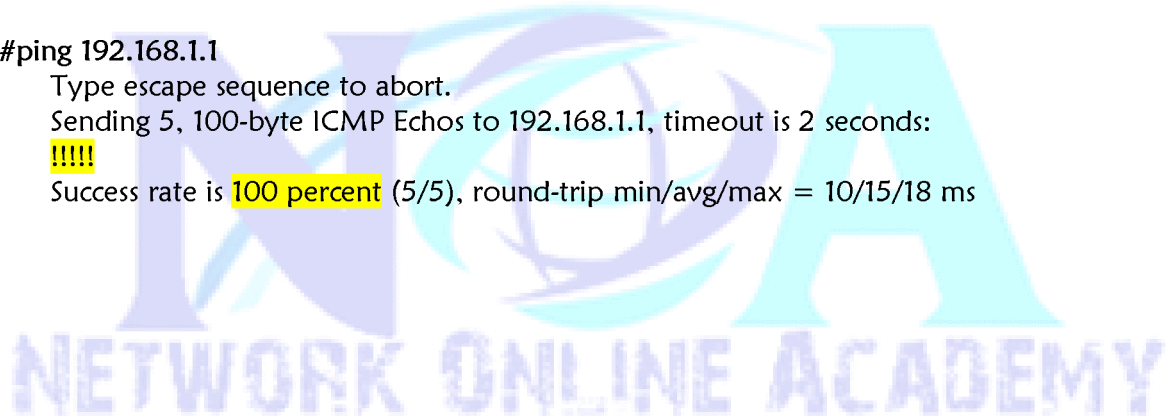
R-3#ping 192.168.1.1

Type escape sequence to abort.

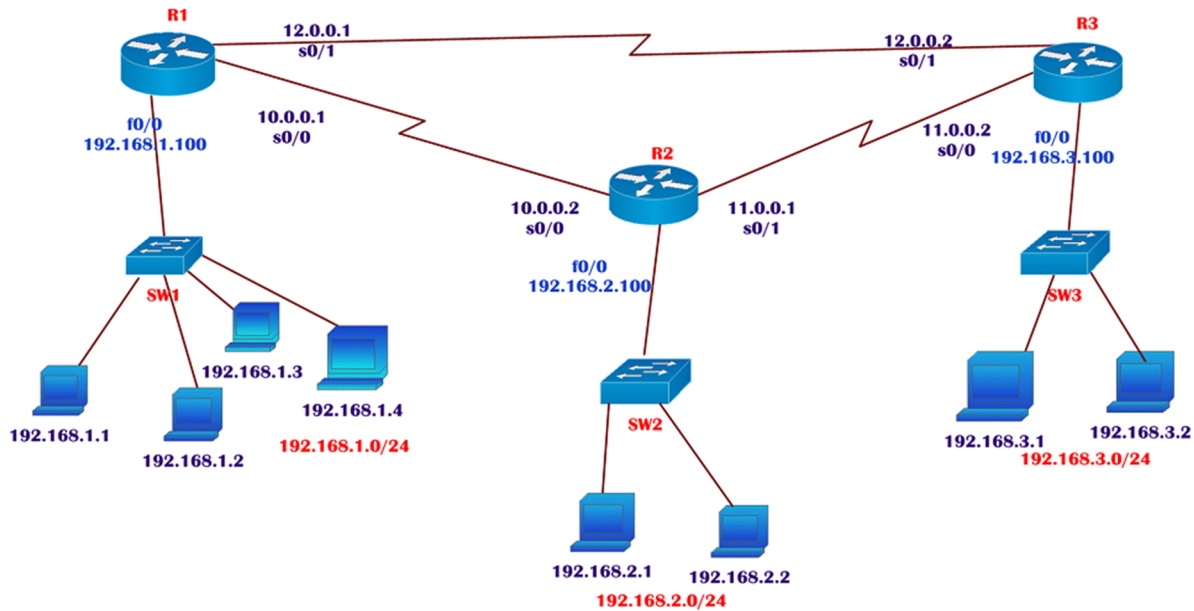
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 10/15/18 ms



LAB: EIGRP – Redundant links



R-1#sh ip int brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.1.100	YES	manual	up	up
Serial0/0	10.0.0.1	YES	manual	up	up
Serial0/1	12.0.0.1	YES	manual	up	up

R-1#sh ip route

Gateway of last resort is not set
 C 10.0.0.0/8 is directly connected, Serial0/0
 C 12.0.0.0/8 is directly connected, Serial0/1
 C 192.168.1.0/24 is directly connected, FastEthernet0/0

R-1(config)#router eigrp 100

R-1(config-router)#network 192.168.1.0

R-1(config-router)#network 10.0.0.0

R-1(config-router)#network 12.0.0.0

R-1(config-router)#exit

R-2#sh ip int brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.2.100	YES	manual	up	up
Serial0/0	10.0.0.2	YES	manual	up	up
Serial0/1	11.0.0.1	YES	manual	up	up

R-2#sh ip route

Gateway of last resort is not set
 C 10.0.0.0/8 is directly connected, Serial0/0
 C 11.0.0.0/8 is directly connected, Serial0/1
 C 192.168.2.0/24 is directly connected, FastEthernet0/0

R-2(config)#router eigrp 100

```
R-2(config-router)#network 192.168.2.0
R-2(config-router)#network 10.0.0.0
R-2(config-router)#network 11.0.0.0
R-2(config-router)#end
```

R-3#sh ip int brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.3.100	YES	manual	up	up
Serial0/0	11.0.0.2	YES	manual	up	up
Serial0/1	12.0.0.2	YES	manual	up	up

R-3#sh ip route

```
Gateway of last resort is not set
C 11.0.0.0/8 is directly connected, Serial0/0
C 12.0.0.0/8 is directly connected, Serial0/1
C 192.168.3.0/24 is directly connected, FastEthernet0/0
```

```
R-3(config)#router eigrp 100
R-3(config-router)#network 192.168.3.0
R-3(config-router)#network 12.0.0.0
R-3(config-router)#network 12.0.0.0
R-3(config-router)#end
```

R-3#sh ip eigrp neighbors

```
IP-EIGRP neighbors for process 100
H Address Interface Hold Uptime SRTT RTO Q Seq
(sec) (ms) Cnt Num
0 12.0.0.1 Se0/1 10 00:00:56 40 1000 0 8
1 11.0.0.1 Se0/0 10 00:00:49 40 1000 0 12
```

R-3#sh ip route eigrp

```
D 10.0.0.0/8 [90/2681856] via 12.0.0.1, 00:01:18, Serial0/1
[90/2681856] via 11.0.0.1, 00:01:11, Serial0/0
D 192.168.1.0/24 [90/2172416] via 12.0.0.1, 00:01:18, Serial0/1
D 192.168.2.0/24 [90/2172416] via 11.0.0.1, 00:01:11, Serial0/0
```

R-3#sh ip eigrp topology

```
IP-EIGRP Topology Table for AS 100/ID(192.168.3.100)
```

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
r - Reply status

```
P 10.0.0.0/8, 2 successors, FD is 2681856
via 12.0.0.1 (2681856/2169856), Serial0/1
via 11.0.0.1 (2681856/2169856), Serial0/0
P 11.0.0.0/8, 1 successors, FD is 2169856
via Connected, Serial0/0
P 12.0.0.0/8, 1 successors, FD is 2169856
via Connected, Serial0/1
```


P 192.168.1.0/24, 1 successors, FD is 2172416
 via 12.0.0.1 (2172416/28160), Serial0/1
 P 192.168.2.0/24, 1 successors, FD is 2172416
 via 11.0.0.1 (2172416/28160), Serial0/0
 P 192.168.3.0/24, 1 successors, FD is 28160
 via Connected, FastEthernet0/0

R-1#sh ip eigrp neighbors

IP-EIGRP neighbors for process 100

H	Address	Interface	Hold (sec)	Uptime (ms)	SRTT Cnt	RTO Num	Q	Seq
0	10.0.0.2	Se0/0	10	00:08:10	40	1000	0	11
1	12.0.0.2	Se0/1	11	00:05:30	40	1000	0	13

R-1#sh ip route eigrp

D 11.0.0.0/8 [90/2681856] via 10.0.0.2, 00:08:39, Serial0/0
 [90/2681856] via 12.0.0.2, 00:06:42, Serial0/1
 D 192.168.2.0/24 [90/2172416] via 10.0.0.2, 00:09:29, Serial0/0
 D 192.168.3.0/24 [90/2172416] via 12.0.0.2, 00:06:49, Serial0/1

R-1#sh ip eigrp topology

IP-EIGRP Topology Table for AS 100/ID(192.168.1.100)

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
 r - Reply status

P 10.0.0.0/8, 1 successors, FD is 2169856
 via Connected, Serial0/0
 P 11.0.0.0/8, 2 successors, FD is 2681856
 via 10.0.0.2 (2681856/2169856), Serial0/0
 via 12.0.0.2 (2681856/2169856), Serial0/1
 P 12.0.0.0/8, 1 successors, FD is 2169856
 via Connected, Serial0/1
 P 192.168.1.0/24, 1 successors, FD is 28160
 via Connected, FastEthernet0/0
 P 192.168.2.0/24, 1 successors, FD is 2172416
 via 10.0.0.2 (2172416/28160), Serial0/0
 P 192.168.3.0/24, 1 successors, FD is 2172416
 via 12.0.0.2 (2172416/28160), Serial0/1

PC>ping 192.168.3.1

Pinging 192.168.3.1 with 32 bytes of data:

Reply from 192.168.3.1: bytes=32 time=10ms TTL=126
 Reply from 192.168.3.1: bytes=32 time=11ms TTL=126
 Reply from 192.168.3.1: bytes=32 time=11ms TTL=126
 Reply from 192.168.3.1: bytes=32 time=11ms TTL=126

Ping statistics for 192.168.3.1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
Minimum = 10ms, Maximum = 11ms, Average = 10ms

PC>tracert 192.168.3.1

Tracing route to 192.168.3.1 over a maximum of 30 hops:

1	1 ms	0 ms	0 ms	192.168.1.100
2	0 ms	0 ms	0 ms	12.0.0.2
3	0 ms	11 ms	11 ms	192.168.3.1

Trace complete.

PC>tracert 192.168.2.1

Tracing route to 192.168.2.1 over a maximum of 30 hops:

1	1 ms	0 ms	0 ms	192.168.1.100
2	1 ms	1 ms	1 ms	10.0.0.2
3	11 ms	11 ms	11 ms	192.168.2.1

Trace complete.

```
R-1(config)#int s0/0
R-1(config-if)#shutdown
R-1(config-if)#end
```

R-1#sh ip eigrp neighbors

IP-EIGRP neighbors for process 100

H	Address	Interface	Hold Uptime	SRTT	RTO	Q	Seq
		(sec)	(ms)	Cnt	Num		
0	12.0.0.2	Se0/1	10 00:09:55	40	1000	0	18

R-1#sh ip eigrp topology

IP-EIGRP Topology Table for AS 100/ID(192.168.1.100)

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
r - Reply status

P 11.0.0.0/8, 1 successors, FD is 2681856
via 12.0.0.2 (2681856/2169856), Serial0/1
P 12.0.0.0/8, 1 successors, FD is 2169856
via Connected, Serial0/1
P 192.168.1.0/24, 1 successors, FD is 28160
via Connected, FastEthernet0/0
P 192.168.2.0/24, 1 successors, FD is 2684416
via 12.0.0.2 (2684416/2172416), Serial0/1
P 192.168.3.0/24, 1 successors, FD is 2172416
via 12.0.0.2 (2172416/28160), Serial0/1

PC>tracert 192.168.3.1

Tracing route to 192.168.3.1 over a maximum of 30 hops:

1	1 ms	3 ms	0 ms	192.168.1.100
2	1 ms	1 ms	0 ms	12.0.0.2
3	11 ms	0 ms	12 ms	192.168.3.1

Trace complete.

```
R-1(config)#int s0/0
R-1(config-if)#no shutdown
R-1(config-if)#end
```

```
R-1#sh ip eigrp neighbors
IP-EIGRP neighbors for process 100
H  Address      Interface      Hold Uptime    SRTT  RTO  Q  Seq
   (sec)         (ms)          Cnt  Num
0  12.0.0.2      Se0/1         11  00:11:55  40   1000  0  20
1  10.0.0.2      Se0/0         14  00:00:02  40   1000  0  21
```

```
R-1#sh ip route eigrp
D  11.0.0.0/8 [90/2681856] via 12.0.0.2, 00:12:02, Serial0/1
   [90/2681856] via 10.0.0.2, 00:00:16, Serial0/0
D  192.168.2.0/24 [90/2172416] via 10.0.0.2, 00:00:16, Serial0/0
D  192.168.3.0/24 [90/2172416] via 12.0.0.2, 00:12:09, Serial0/1
```

```
R-1#traceroute 192.168.3.1
Type escape sequence to abort.
Tracing the route to 192.168.3.1
```

1	12.0.0.2	1 msec	2 msec	1 msec
2	192.168.3.1	0 msec	1 msec	1 msec

OSPF

- ▶ OSPF stand for Open Shortest path first
- ▶ It's a link state protocol
- ▶ Standard protocol
- ▶ It uses SPF (shortest path first) or dijkistra algorithm
- ▶ Unlimited hop count
- ▶ Metric is cost ($\text{cost} = 10^8 / \text{B.W.}$)
- ▶ Administrative distance is 110
- ▶ It is a classless routing protocol (carry subnet-mask information & supports VLSM)
- ▶ Supports equal cost load balancing.

Basic OSPF process

Seven stages

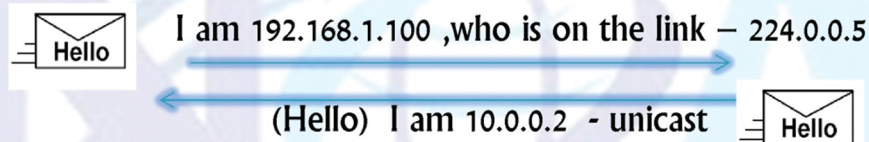
1. Down
2. Init
3. 2 way
4. Exstart
5. Exchange
6. Loading
7. Full

OSPF Basic process – seven stages



Down stage

Init stage

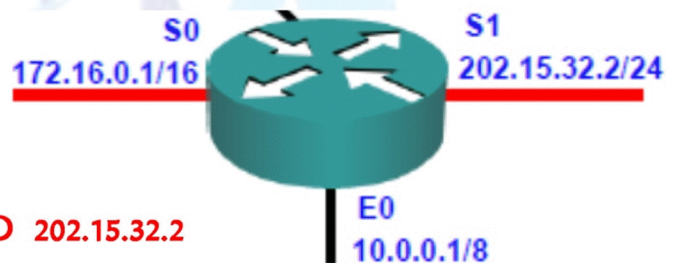


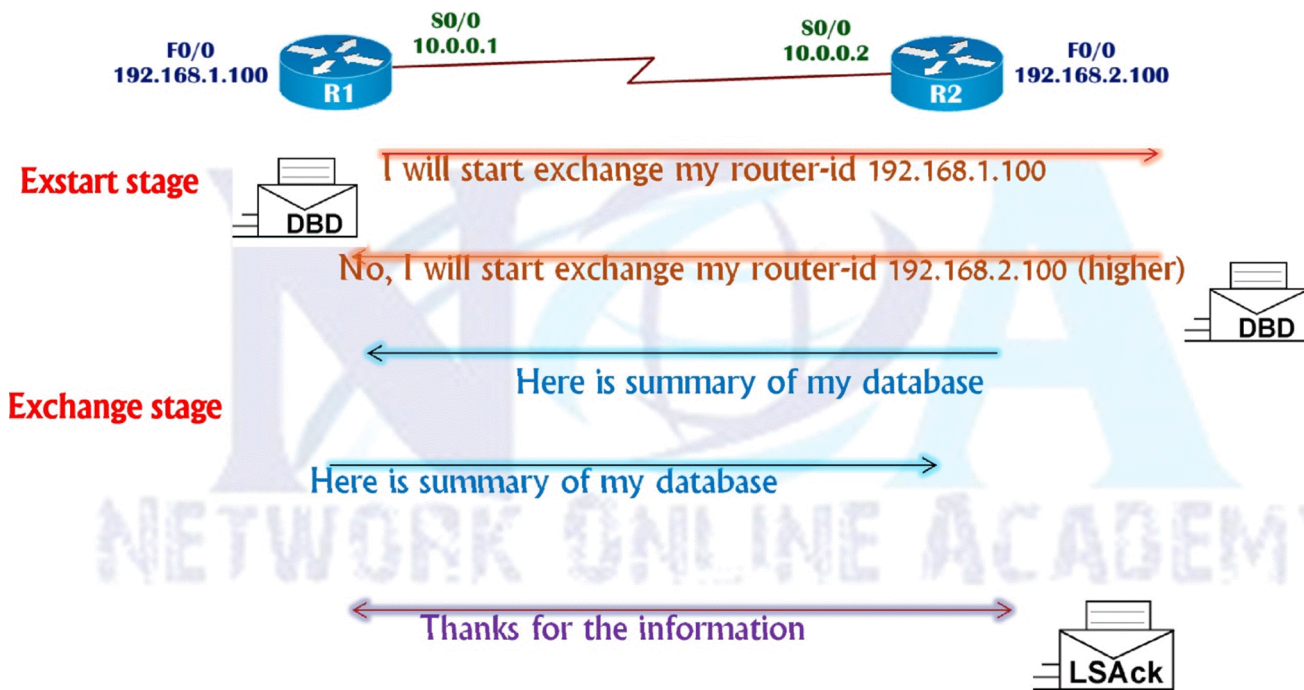
Two-way stage

They become neighbors, built **neighbor table**

OSPF router-ID

- used to identify the router inside the OSPF database.
- OSPF identify using same ID in all directions.
- Default uses highest IP address of active physical interface.

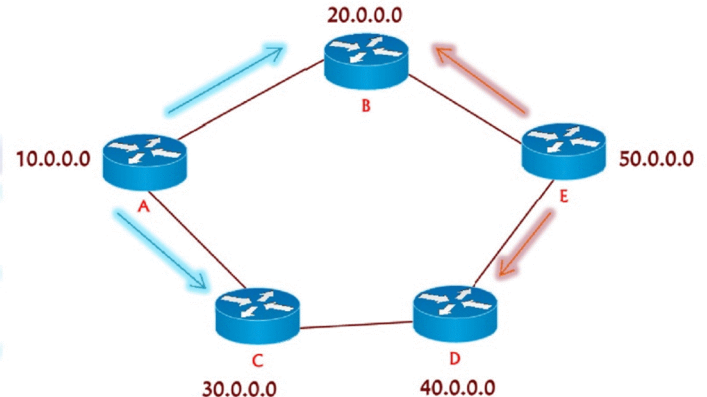




OSPF tables

Neighbor table

- Contains list of directly connected routers
- # show ip ospf neighbor



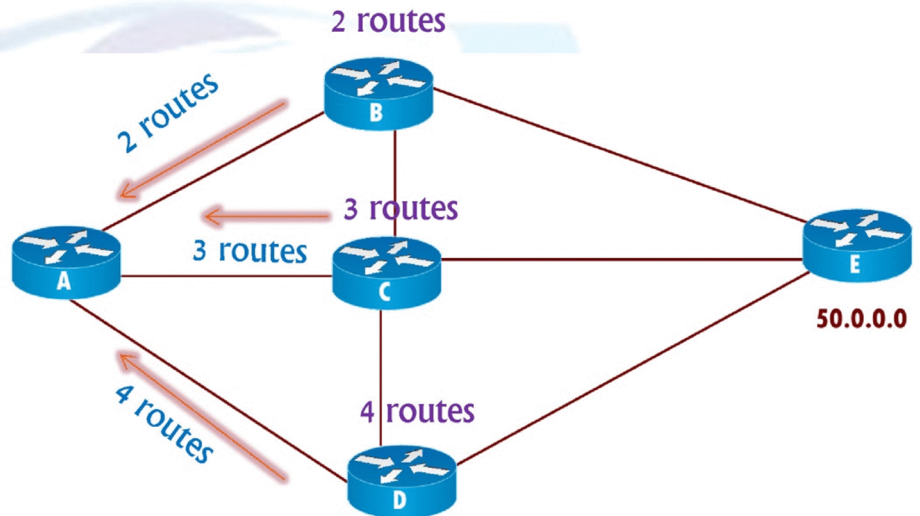
Routing table

- The best route to the destination
- # show ip route

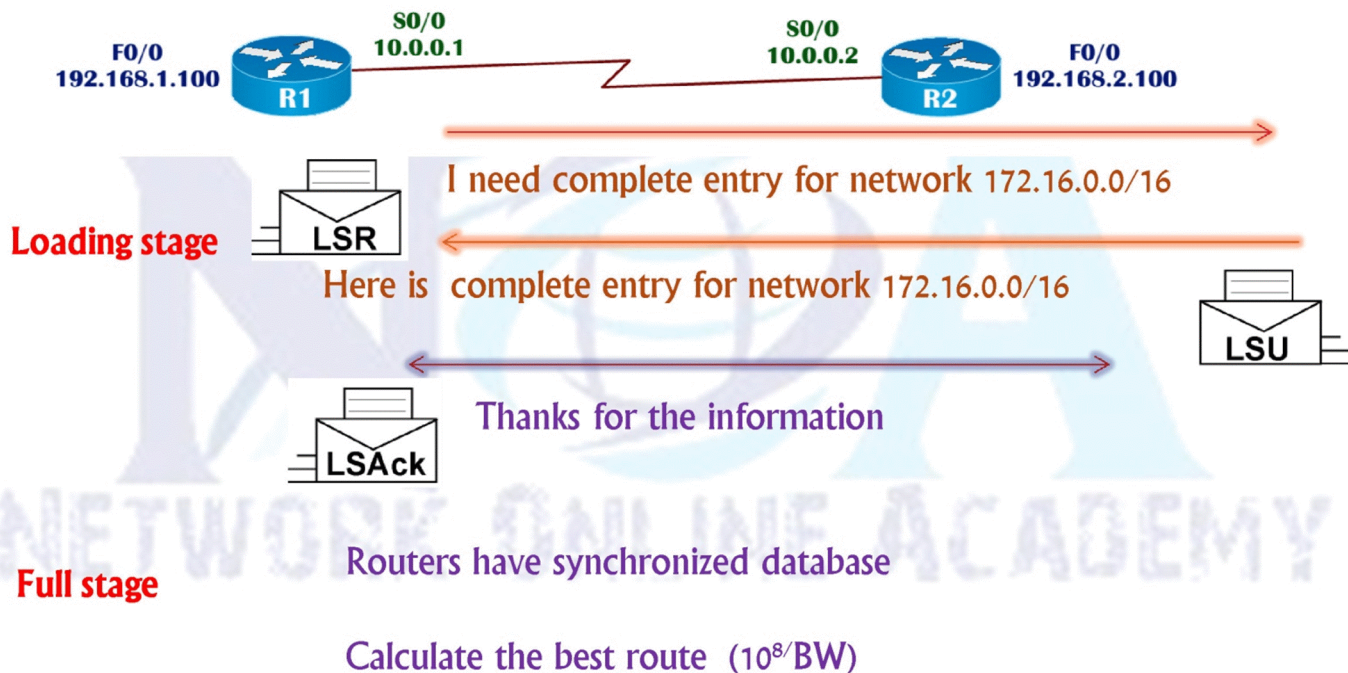
Database Table

- referred to as LSDB (link state database)
- Contains information about all the possible routes to the networks within the area
- # show ip ospf database

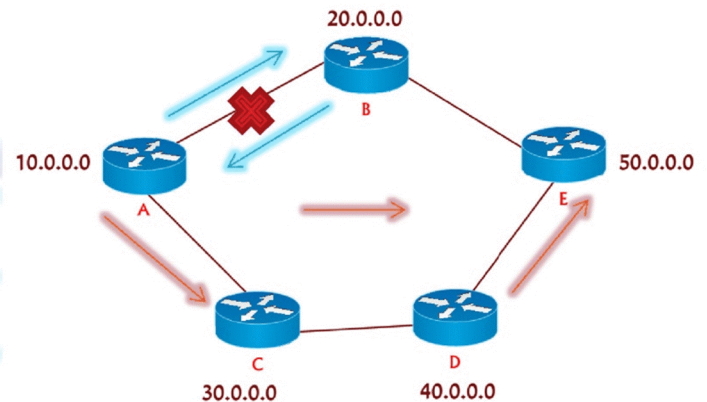
OSPF Tables



All the routers must have the same database

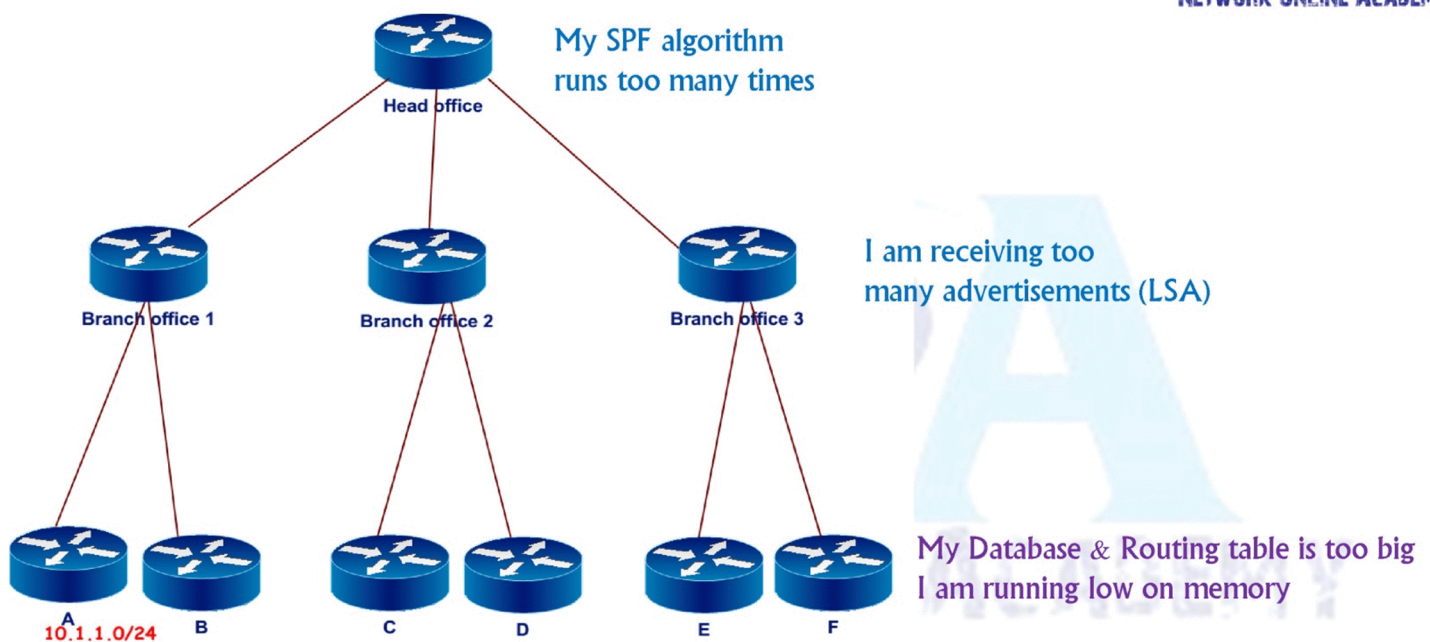


OSPF Convergence



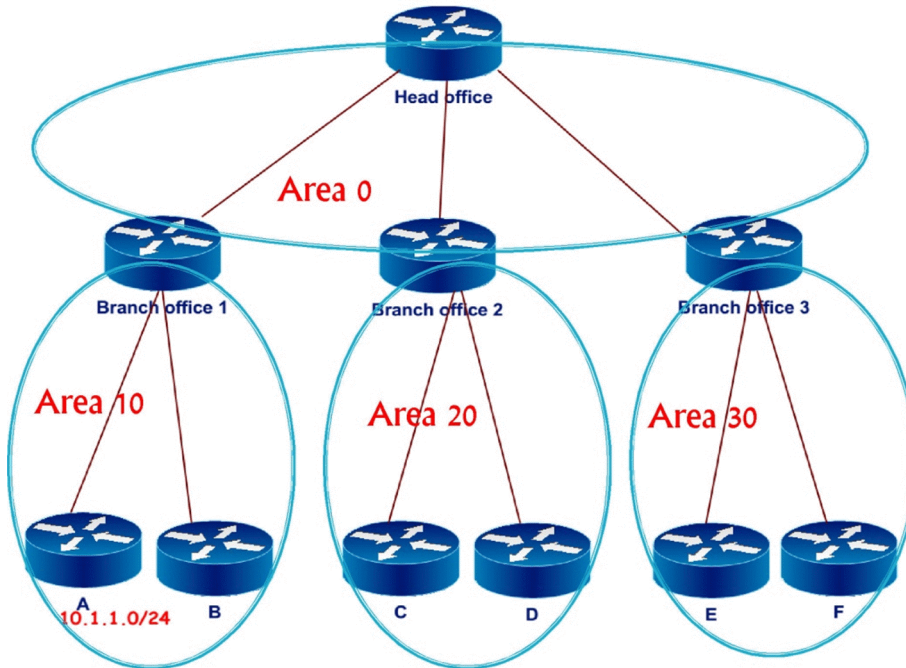
- ▶ Incremental updates
- ▶ Periodically send hello packets are sent every 10 seconds (dead – 40 sec)
- ▶ Convergence rate is fast (40 sec)

Issues with Maintaining a Large OSPF Network



- All the routers must have the same database.
- Any change in the database advertised to all routers.

Issues with Maintaining a Large OSPF Network



Solution : OSPF areas

Area is logical grouping of Routers.

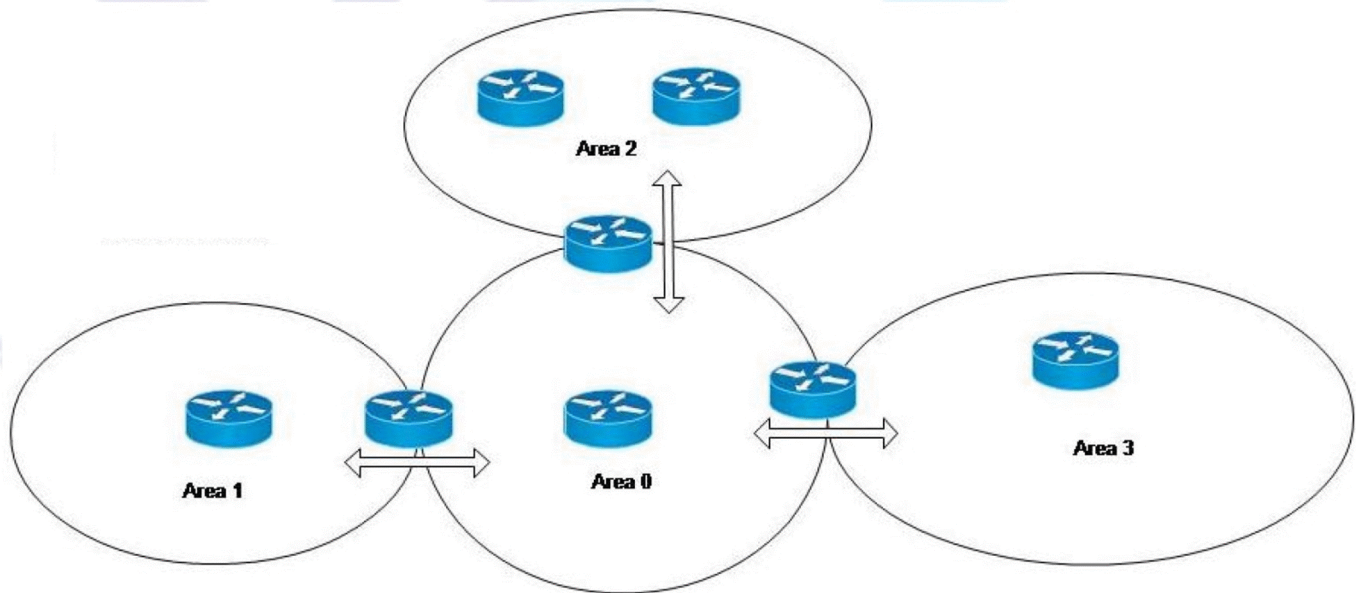
- All the routers must have the same database with in area
- Any change in the database advertised to all routers with in area

Concept of areas

- ▶ Area is logical grouping of Routers .
- ▶ All the routers maintain same database with in the same Area.
- ▶ Any change impact all the routers with the same area.
- ▶ Minimizes size of database
- ▶ Restrict any changes with in that area. (not flood outside area)
- ▶ Routers with in the same area participate in Algorithm

OSPF area design Rules

- ▶ Must have one area called as area 0 (its backbone area)
- ▶ All the non-backbone areas must connect to area 0. (Area 0 must be transit area)
- ▶ At least one Area Border Router (connecting two or more areas) .
- ▶ Interfaces of both routers facing must be in the same Area.

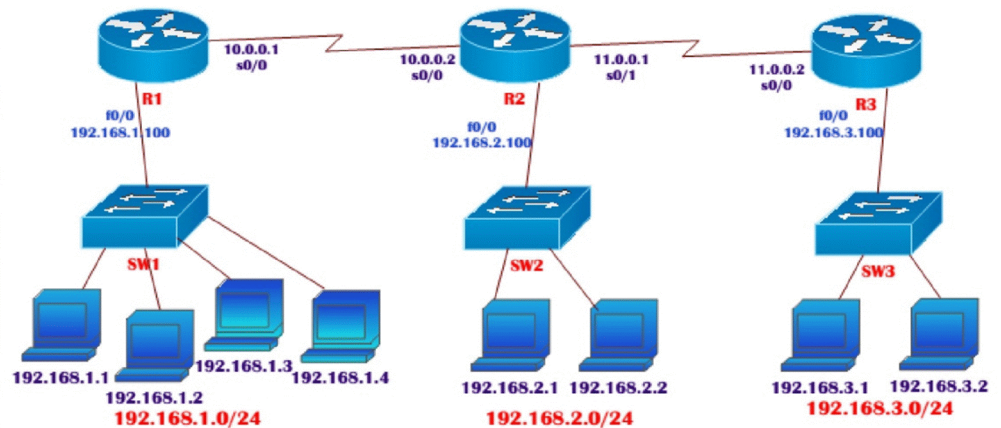


NETWORK ONLINE ACADEMY

Configuring OSPF

(config)# **router ospf** <process ID>

(config-router)# **network** <Network ID> <wildcard mask> **area** <area id>



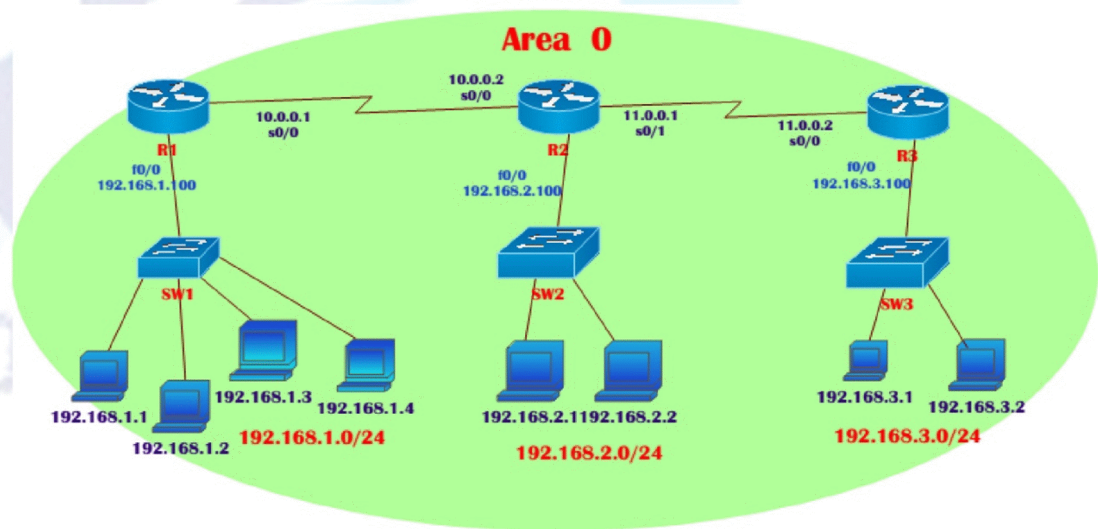
- Process ID is a number used to identify an OSPF routing process on the router.
- Multiple OSPF processes can be started on the same router.
- The number can be any value between 1 and 65,535.

LAB: OSPF Single Area

R-1(config)#**router ospf** 1

R-1(config-router)#**network** 192.168.1.0 0.0.0.255 **area** 0

R-1(config-router)#**network** 10.0.0.0 0.255.255.255 **area** 0



R-2(config)#router ospf 1

R-2(config-router)#network 192.168.2.0 0.0.0.255 area 0

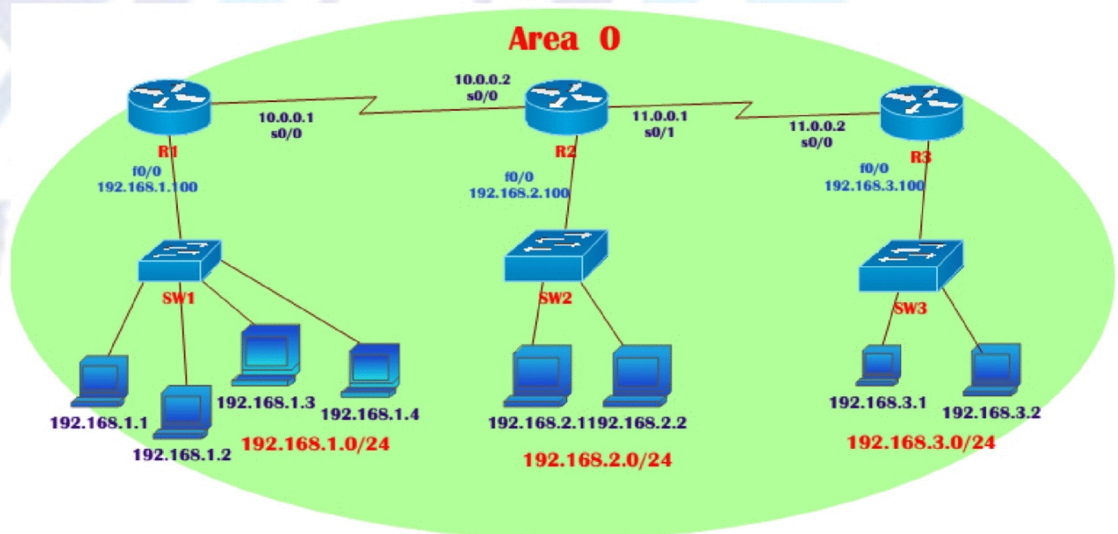
R-2(config-router)#network 11.0.0.0 0.255.255.255 area 0

R-2(config-router)#network 10.0.0.0 0.255.255.255 area 0

R-3(config)#router ospf 1

R-3(config-router)#network 192.168.3.0 0.0.0.255 area 0

R-3(config-router)#network 11.0.0.0 0.255.255.255 area 0

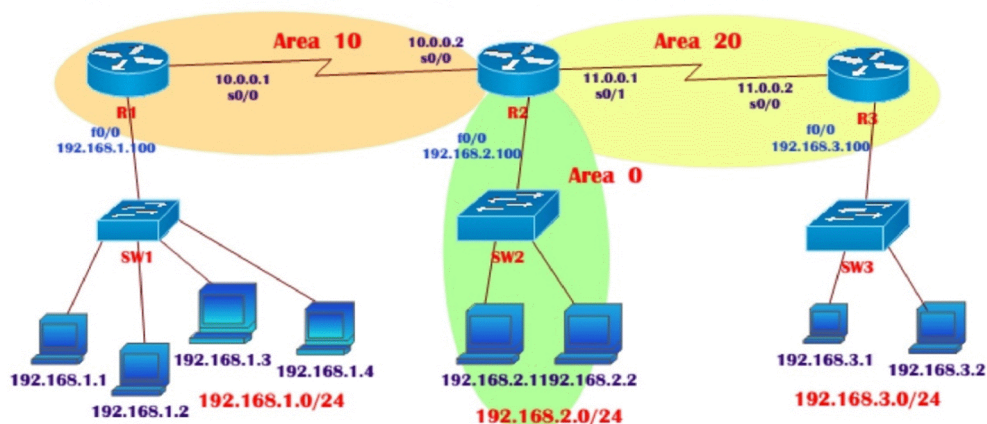


LAB: OSPF using Multiple Areas

R-1(config)#router ospf 1

R-1(config-router)#network 192.168.1.0 0.0.0.255 area 10

R-1(config-router)#network 10.0.0.0 0.255.255.255 area 10



R-2(config)#router ospf 1

R-2(config-router)#network 192.168.2.0 0.0.0.255 area 0

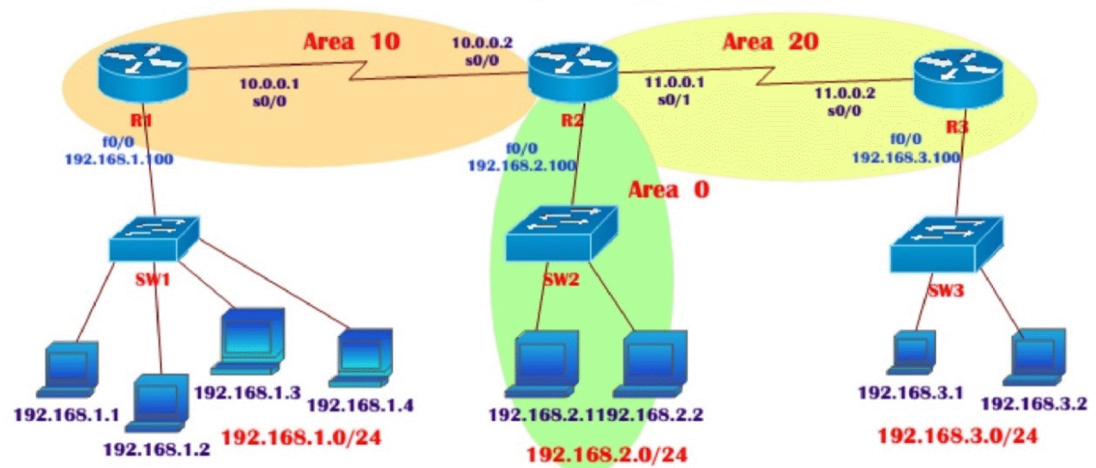
R-2(config-router)#network 11.0.0.0 0.255.255.255 area 20

R-2(config-router)#network 10.0.0.0 0.255.255.255 area 10

R-3(config)#router ospf 1

R-3(config-router)#network 192.168.3.0 0.0.0.255 area 20

R-3(config-router)#network 11.0.0.0 0.255.255.255 area 20



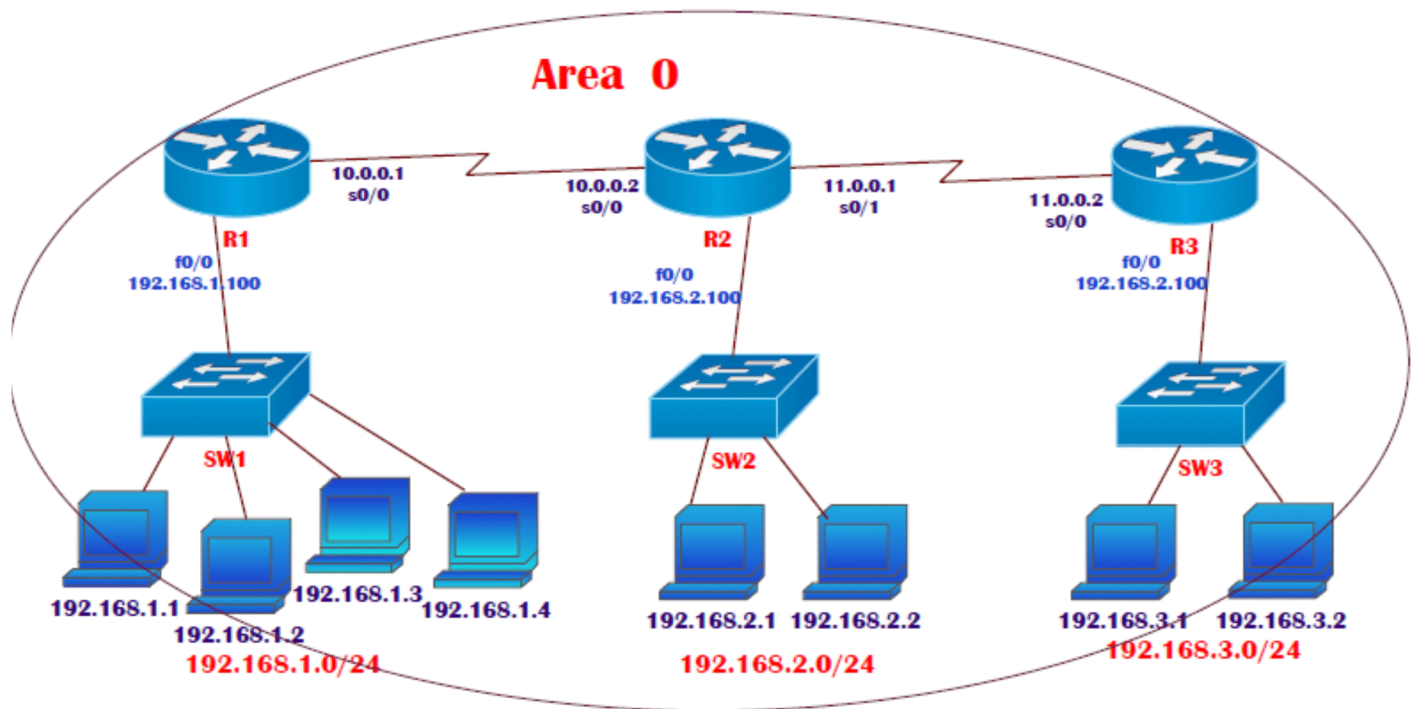
Advantages of OSPF

- Open standard
- No hop count limitations
- Faster convergence

Disadvantages of OSPF

- Consume more CPU resources.
- Complex design rules

LAB: DYNAMIC ROUTING USING OSPF IN SINGLE AREA



Pre-requirement for LAB (check previous labs)

- Design the topology (connectivity)
- Assign the IP address according to diagram
- Make sure that interfaces used should be in UP UP state

TASK

- Configure Dynamic routing using OSPF single area as per the diagram
- Verify Routing table and reachability between the LAN's (using PING and TRACE commands)

R-1#sh ip route

Gateway of last resort is not set

C 10.0.0.0/8 is directly connected, Serial0/0

C 192.168.1.0/24 is directly connected, FastEthernet0/0

R-2#sh ip route

Gateway of last resort is not set

C 10.0.0.0/8 is directly connected, Serial0/0

C 11.0.0.0/8 is directly connected, Serial0/1

C 192.168.2.0/24 is directly connected, FastEthernet0/0

R-3#sh ip route

Gateway of last resort is not set

C 11.0.0.0/8 is directly connected, Serial0/0

C 192.168.3.0/24 is directly connected, FastEthernet0/0

Router- 1

```
R-1(config)#router ospf 1
```

```
R-1(config-router)#network 192.168.1.0 0.0.0.255 area 0
```

```
R-1(config-router)#network 10.0.0.0 0.255.255.255 area 0
```

Router – 2

```
R-2(config)#router ospf 1
```

```
R-2(config-router)#network 192.168.2.0 0.0.0.255 area 0
```

```
R-2(config-router)#network 11.0.0.0 0.255.255.255 area 0
```

```
R-2(config-router)#network 10.0.0.0 0.255.255.255 area 0
```

```
06:14:49: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.1.100 on Serial0/0 from LOADING to FULL, Loading Done
```

Router – 3

```
R-3(config)#router ospf 1
```

```
R-3(config-router)#network 192.168.3.0 0.0.0.255 area 0
```

```
R-3(config-router)#network 11.0.0.0 0.255.255.255 area 0
```

```
06:15:46: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.2.100 on Serial0/0 from LOADING to FULL, Loading Done
```

```
R-2#show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
192.168.1.100	0	FULL/ -	00:00:35	10.0.0.1	Serial0/0
192.168.3.100	0	FULL/ -	00:00:37	11.0.0.2	Serial0/1

```
R-1#show ip route
```

```
Gateway of last resort is not set
```

```
C 10.0.0.0/8 is directly connected, Serial0/0
```

```
O 11.0.0.0/8 [110/128] via 10.0.0.2, 00:04:21, Serial0/0
```

```
C 192.168.1.0/24 is directly connected, FastEthernet0/0
```

```
O 192.168.2.0/24 [110/65] via 10.0.0.2, 00:04:21, Serial0/0
```

```
O 192.168.3.0/24 [110/129] via 10.0.0.2, 00:03:19, Serial0/0
```

```
R-1#sh ip route ospf
```

```
O 11.0.0.0 [110/128] via 10.0.0.2, 00:04:25, Serial0/0
```

```
O 192.168.2.0 [110/65] via 10.0.0.2, 00:04:25, Serial0/0
```

```
O 192.168.3.0 [110/129] via 10.0.0.2, 00:03:23, Serial0/0
```

```
R-2#show ip route ospf
```

```
O 192.168.1.0 [110/65] via 10.0.0.1, 00:05:09, Serial0/0
```

```
O 192.168.3.0 [110/65] via 11.0.0.2, 00:04:14, Serial0/1
```


R-3#show ip route ospf

- 10.0.0.0 [110/128] via 11.0.0.1, 00:04:49, Serial0/0
- 192.168.1.0 [110/129] via 11.0.0.1, 00:04:49, Serial0/0
- 192.168.2.0 [110/65] via 11.0.0.1, 00:04:49, Serial0/0

R-1#show ip protocols

Routing Protocol is "ospf 1"

Outgoing update filter list for all interfaces is not set

Incoming update filter list for all interfaces is not set

Router ID 192.168.1.100

Number of areas in this router is 1. 1 normal 0 stub 0 nssa

Maximum path: 4

Routing for Networks:

192.0.0.0 0.0.0.255 area 0

10.0.0.0 0.255.255.255 area 0

Routing Information Sources:

Gateway	Distance	Last Update
10.0.0.2	110	00:05:46

Distance: (default is 110)

R-1#show ip ospf database

OSPF Router with ID (192.168.1.100) (Process ID 1)

Router Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
192.168.1.100	192.168.1.100	468	0x80000003	0x00d1f4	3
192.168.2.100	192.168.2.100	411	0x80000005	0x0054e6	5
192.168.3.100	192.168.3.100	411	0x80000003	0x0010ad	3

PC>ipconfig

IP Address.....: 192.168.1.1
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 192.168.1.100

PC>ping 192.168.2.1

Pinging 192.168.2.1 with 32 bytes of data:

Request timed out.

Reply from 192.168.2.1: bytes=32 time=19ms TTL=126

Reply from 192.168.2.1: bytes=32 time=20ms TTL=126

Reply from 192.168.2.1: bytes=32 time=14ms TTL=126

PC>ping 192.168.3.1

Pinging 192.168.3.1 with 32 bytes of data:

Request timed out.

Reply from 192.168.3.1: bytes=32 time=27ms TTL=125

Reply from 192.168.3.1: bytes=32 time=22ms TTL=125

Reply from 192.168.3.1: bytes=32 time=25ms TTL=125

PC>tracert 192.168.3.1

Tracing route to 192.168.3.1 over a maximum of 30 hops:

1	5 ms	8 ms	8 ms	192.168.1.100
2	12 ms	9 ms	8 ms	10.0.0.2
3	17 ms	6 ms	12 ms	11.0.0.2
4	24 ms	27 ms	25 ms	192.168.3.1

Trace complete.

R-1#ping 192.168.3.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.3.1, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 9/16/31 ms

R-3#ping 192.168.1.1

Type escape sequence to abort.

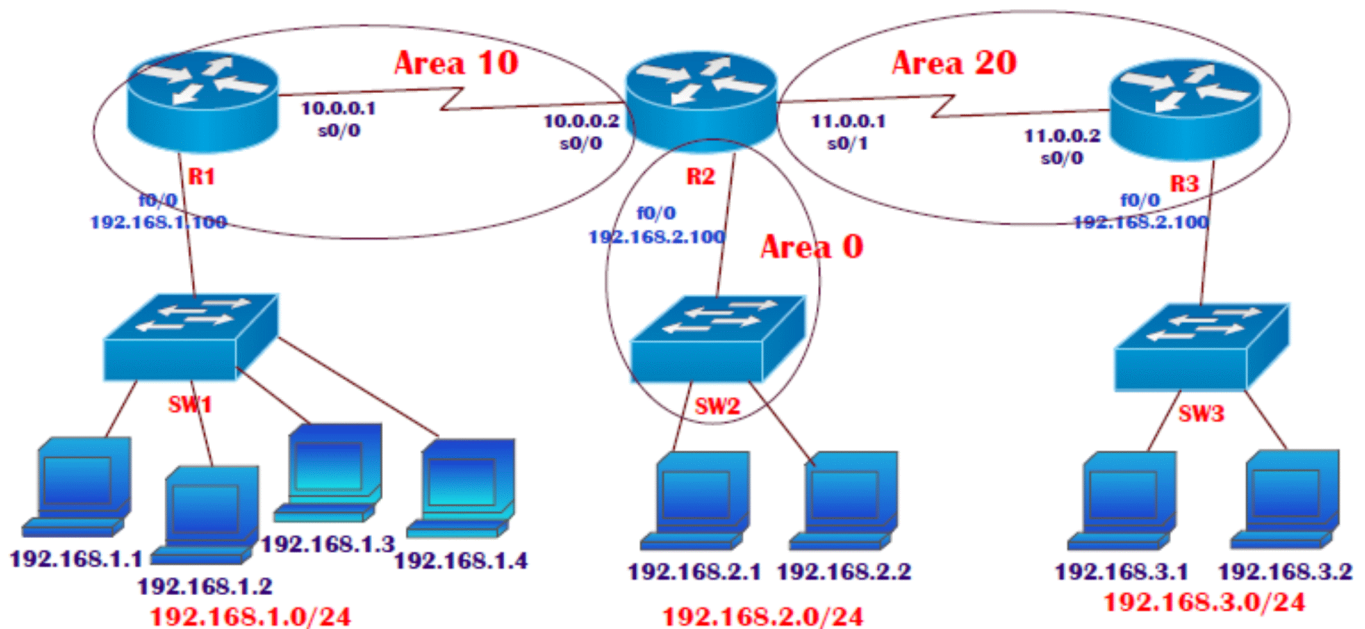
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 10/15/18 ms



LAB: DYNAMIC ROUTING USING OSPF MULTIPLE AREA



Pre-requirement for LAB (check previous labs)

- Design the topology (connectivity)
- Assign the IP address according to diagram
- Make sure that interfaces used should be in UP state

TASK:

- Dynamic routing using OSPF multiple area
- Verify Routing table and reachability between the LAN's (using PING and TRACE commands)

R-1#sh ip route

Gateway of last resort is not set

C 10.0.0.0/8 is directly connected, Serial0/0

C 192.168.1.0/24 is directly connected, FastEthernet0/0

R-2#sh ip route

Gateway of last resort is not set

C 10.0.0.0/8 is directly connected, Serial0/0

C 11.0.0.0/8 is directly connected, Serial0/1

C 192.168.2.0/24 is directly connected, FastEthernet0/0

R-3#sh ip route

Gateway of last resort is not set

C 11.0.0.0/8 is directly connected, Serial0/0

C 192.168.3.0/24 is directly connected, FastEthernet0/0

Router- 1


```
R-1(config)#router ospf 1
```

```
R-1(config-router)#network 192.168.1.0 0.0.0.255 area 10
```

```
R-1(config-router)#network 10.0.0.0 0.255.255.255 area 10
```

Router – 2

```
R-2(config)#router ospf 1
```

```
R-2(config-router)#network 192.168.2.0 0.0.0.255 area 0
```

```
R-2(config-router)#network 11.0.0.0 0.255.255.255 area 20
```

```
R-2(config-router)#network 10.0.0.0 0.255.255.255 area 10
```

```
06:14:49: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.1.100 on Serial0/0 from LOADING to FULL, Loading Done
```

Router – 3

```
R-3(config)#router ospf 1
```

```
R-3(config-router)#network 192.168.3.0 0.0.0.255 area 20
```

```
R-3(config-router)#network 11.0.0.0 0.255.255.255 area 20
```

```
06:15:46: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.2.100 on Serial0/0 from LOADING to FULL, Loading Done
```

```
R-2#show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
192.168.3.100	0	FULL/ -	00:00:39	11.0.0.2	Serial0/1
192.168.1.100	0	FULL/ -	00:00:39	10.0.0.1	Serial0/0

```
R-1#show ip route
```

```
Gateway of last resort is not set
```

```
C 10.0.0.0/8 is directly connected, Serial0/0
```

```
O IA 11.0.0.0/8 [110/128] via 10.0.0.2, 00:06:39, Serial0/0
```

```
C 192.168.1.0/24 is directly connected, FastEthernet0/0
```

```
O IA 192.168.2.0/24 [110/65] via 10.0.0.2, 00:06:39, Serial0/0
```

```
O IA 192.168.3.0/24 [110/129] via 10.0.0.2, 00:06:07, Serial0/0
```

```
R-1#show ip route ospf
```

```
O IA 11.0.0.0 [110/128] via 10.0.0.2, 00:06:24, Serial0/0
```

```
O IA 192.168.2.0 [110/65] via 10.0.0.2, 00:06:24, Serial0/0
```

```
O IA 192.168.3.0 [110/129] via 10.0.0.2, 00:05:53, Serial0/0
```

```
R-2#show ip route ospf
```

```
O 192.168.1.0 [110/65] via 10.0.0.1, 00:08:31, Serial0/0
```

```
O 192.168.3.0 [110/65] via 11.0.0.2, 00:08:04, Serial0/1
```

R-3#show ip route ospf

- IA 10.0.0.0 [110/128] via 11.0.0.1, 00:08:21, Serial0/0
- IA 192.168.1.0 [110/129] via 11.0.0.1, 00:08:21, Serial0/0
- IA 192.168.2.0 [110/65] via 11.0.0.1, 00:08:21, Serial0/0

R-1#sh ip ospf database

OSPF Router with ID (192.168.1.100) (Process ID 1)

Router Link States (Area 10)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
192.168.1.100	192.168.1.100	902	0x80000003	0x003b8b	3
192.168.2.100	192.168.2.100	902	0x80000002	0x00e758	2

Summary Net Link States (Area 10)

Link ID	ADV Router	Age	Seq#	Checksum
192.168.2.0	192.168.2.100	905	0x80000001	0x0057cb
11.0.0.0	192.168.2.100	905	0x80000002	0x00063d
192.168.3.0	192.168.2.100	870	0x80000003	0x00ca15

R-2#show ip ospf database

OSPF Router with ID (192.168.2.100) (Process ID 1)

Router Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
192.168.2.100	192.168.2.100	708	0x80000002	0x0070d6	1

Summary Net Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum
11.0.0.0	192.168.2.100	698	0x80000001	0x00083c
10.0.0.0	192.168.2.100	689	0x80000002	0x001331
192.168.1.0	192.168.2.100	689	0x80000003	0x00e001
192.168.3.0	192.168.2.100	663	0x80000004	0x00c816

Router Link States (Area 10)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
192.168.2.100	192.168.2.100	694	0x80000002	0x00e758	2
192.168.1.100	192.168.1.100	694	0x80000003	0x003b8b	3

Summary Net Link States (Area 10)

Link ID	ADV Router	Age	Seq#	Checksum
192.168.2.0	192.168.2.100	697	0x80000001	0x0057cb
11.0.0.0	192.168.2.100	697	0x80000002	0x00063d
192.168.3.0	192.168.2.100	662	0x80000003	0x00ca15

Router Link States (Area 20)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
192.168.2.100	192.168.2.100	668	0x80000002	0x000a33	2
192.168.3.100	192.168.3.100	668	0x80000003	0x0010ad	3

Summary Net Link States (Area 20)

Link ID	ADV Router	Age	Seq#	Checksum
192.168.2.0	192.168.2.100	703	0x80000001	0x0057cb
10.0.0.0	192.168.2.100	689	0x80000002	0x001331
192.168.1.0	192.168.2.100	689	0x80000003	0x00e001

PC>ipconfig

IP Address.....: 192.168.1.1
 Subnet Mask.....: 255.255.255.0
 Default Gateway.....: 192.168.1.100

PC>ping 192.168.2.1

Pinging 192.168.2.1 with 32 bytes of data:
 Request timed out.
 Reply from 192.168.2.1: bytes=32 time=19ms TTL=126
 Reply from 192.168.2.1: bytes=32 time=20ms TTL=126
 Reply from 192.168.2.1: bytes=32 time=14ms TTL=126

PC>ping 192.168.3.1

Pinging 192.168.3.1 with 32 bytes of data:
 Request timed out.
 Reply from 192.168.3.1: bytes=32 time=27ms TTL=125
 Reply from 192.168.3.1: bytes=32 time=22ms TTL=125
 Reply from 192.168.3.1: bytes=32 time=25ms TTL=125

PC>tracert 192.168.3.1

Tracing route to 192.168.3.1 over a maximum of 30 hops:
 1 5 ms 8 ms 8 ms 192.168.1.100
 2 12 ms 9 ms 8 ms 10.0.0.2
 3 17 ms 6 ms 12 ms 11.0.0.2
 4 24 ms 27 ms 25 ms 192.168.3.1
 Trace complete.

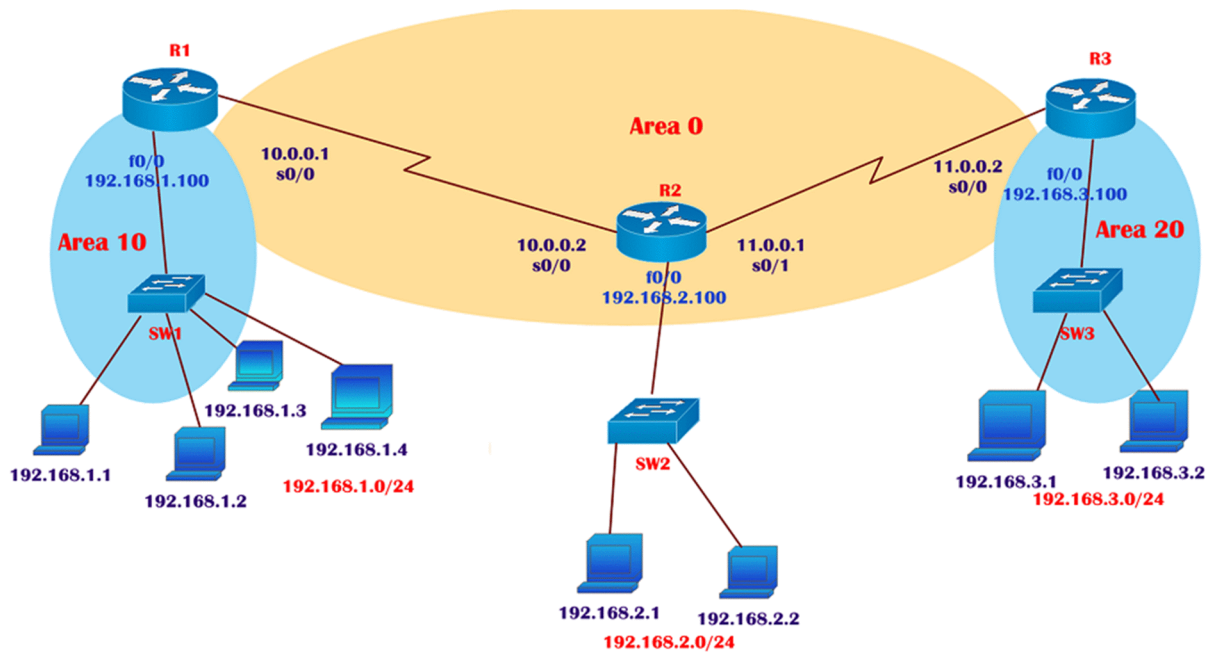
R-1#ping 192.168.3.1

Type escape sequence to abort.
 Sending 5, 100-byte ICMP Echos to 192.168.3.1, timeout is 2 seconds:
 !!!!!
 Success rate is 100 percent (5/5), round-trip min/avg/max = 9/16/31 ms

R-3#ping 192.168.1.1

Type escape sequence to abort.
 Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
 !!!!!
 Success rate is 100 percent (5/5), round-trip min/avg/max = 10/15/18 ms

LAB: OSPF – Redundant Links



```
R-1(config)#router ospf 1
R-1(config-router)# network 10.0.0.0 0.255.255.255 area 0
R-1(config-router)# network 192.168.1.0 0.0.0.255 area 10
R-1(config-router)#exit
```

```
R-2(config)#router ospf 2
R-2(config-router)# network 192.168.2.0 0.0.0.255 area 0
R-2(config-router)# network 10.0.0.0 0.255.255.255 area 0
R-2(config-router)# network 11.0.0.0 0.255.255.255 area 0
R-2(config-router)#end
```

```
R-3(config)# router ospf 3
R-3(config-router)#network 192.168.3.0 0.0.0.255 area 20
R-3(config-router)#network 11.0.0.0 0.255.255.255 area 0
R-3(config-router)#end
```

```
R-3#sh ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
192.168.2.100	0	FULL/ -	00:00:39	11.0.0.1	Serial0/0

```
R-3#sh ip protocols
```

```
Routing Protocol is "ospf 3"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 192.168.3.100
  Number of areas in this router is 2. 2 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    192.168.3.0 0.0.0.255 area 20
    11.0.0.0 0.255.255.255 area 0
```

Routing Information Sources:

Gateway	Distance	Last Update
192.168.1.100	110	00:03:23
192.168.2.100	110	00:01:05
192.168.3.100	110	00:01:05

Distance: (default is 110)

R-3#sh ip route ospf

- 10.0.0.0 [110/128] via 11.0.0.1, 00:01:28, Serial0/0
- IA 192.168.1.0 [110/129] via 11.0.0.1, 00:01:28, Serial0/0
- 192.168.2.0 [110/65] via 11.0.0.1, 00:01:28, Serial0/0

R-2#sh ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface
192.168.1.100	0	FULL/ -	00:00:36	10.0.0.1	Serial0/0
192.168.3.100	0	FULL/ -	00:00:36	11.0.0.2	Serial0/1

R-2#sh ip route ospf

- IA 192.168.1.0 [110/65] via 10.0.0.1, 00:05:31, Serial0/0
- IA 192.168.3.0 [110/65] via 11.0.0.2, 00:03:12, Serial0/1

R-1#sh ip route ospf

- 11.0.0.0 [110/128] via 10.0.0.2, 00:07:05, Serial0/0
- 192.168.2.0 [110/65] via 10.0.0.2, 00:07:05, Serial0/0
- IA 192.168.3.0 [110/129] via 10.0.0.2, 00:04:40, Serial0/0

R-1#sh ip ospf database

OSPF Router with ID (192.168.1.100) (Process ID 1)

Router Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
192.168.1.100	192.168.1.100	480	0x80000002	0x00f44d	2
192.168.2.100	192.168.2.100	341	0x80000005	0x009c9e	5
192.168.3.100	192.168.3.100	341	0x80000002	0x00fc3e	2

Summary Net Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum
192.168.1.0	192.168.1.100	602	0x80000001	0x0069bb
192.168.3.0	192.168.3.100	346	0x80000001	0x0045db

Router Link States (Area 10)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
192.168.1.100	192.168.1.100	607	0x80000002	0x0079d0	1

Summary Net Link States (Area 10)

Link ID	ADV Router	Age	Seq#	Checksum
10.0.0.0	192.168.1.100	624	0x80000001	0x001c2a
192.168.2.0	192.168.1.100	475	0x80000002	0x00de04
11.0.0.0	192.168.1.100	475	0x80000003	0x008d75

192.168.3.0 192.168.1.100 331 0x80000004 0x00524d

R-1#ping 192.168.3.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.3.1, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 2/3/5 ms

R-1#traceroute 192.168.3.1

Type escape sequence to abort.

Tracing the route to 192.168.3.1

1	10.0.0.2	1 msec	1 msec	0 msec
2	11.0.0.2	1 msec	0 msec	1 msec
3	192.168.3.1	1 msec	5 msec	0 msec

TASK:

- Connect Wan link between R1-R3
- Assigning IP address given in int diagram and advertise in ospf area 0

R-1#sh ip int brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.1.100	YES	manual	up	up
Serial0/0	10.0.0.1	YES	manual	up	up
Serial0/1	12.0.0.1	YES	manual	up	up

R-1#ping 12.0.0.2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 12.0.0.2, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/6/28 ms

R-1(config)#router ospf 1

R-1(config-router)#network 12.0.0.0 0.255.255.255 area 0

R-1(config-router)#end

R-3(config)#router ospf 3

R-3(config-router)#network 12.0.0.0 0.255.255.255 area 0

R-3(config-router)#end

R-3#sh ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface
192.168.2.100	0	FULL/ -	00:00:39	11.0.0.1	Serial0/0
192.168.1.100	0	FULL/ -	00:00:33	12.0.0.1	Serial0/1

R-1#sh ip route ospf

- 11.0.0.0 [110/128] via 10.0.0.2, 00:00:57, Serial0/0
[110/128] via 12.0.0.2, 00:00:57, Serial0/1
- 192.168.2.0 [110/65] via 10.0.0.2, 00:18:24, Serial0/0
- IA 192.168.3.0 [110/65] via 12.0.0.2, 00:00:57, Serial0/1

R-1#traceroute 192.168.3.1

Type escape sequence to abort.

Tracing the route to 192.168.3.1

1	12.0.0.2	22 msec	2 msec	2 msec
2	192.168.3.1	1 msec	1 msec	0 msec

R-1(config)#interface serial 0/0

R-1(config-if)#shutdown

R-1(config-if)#exit

R-1(config)#do sh ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface
192.168.3.100	0	FULL/ -	00:00:33	12.0.0.2	Serial0/1

R-1(config)#do sh ip route ospf

- 11.0.0.0 [110/128] via 12.0.0.2, 00:00:21, Serial0/1
- 192.168.2.0 [110/129] via 12.0.0.2, 00:00:21, Serial0/1
- IA 192.168.3.0 [110/65] via 12.0.0.2, 00:02:48, Serial0/1

R-1#traceroute 192.168.3.1

Type escape sequence to abort.

Tracing the route to 192.168.3.1

1	12.0.0.2	2 msec	0 msec	4 msec
2	192.168.3.1	1 msec	0 msec	10 msec

R-1#traceroute 192.168.2.1

Type escape sequence to abort.

Tracing the route to 192.168.2.1

1	12.0.0.2	40 msec	14 msec	2 msec
2	11.0.0.1	2 msec	1 msec	2 msec
3	192.168.2.1	3 msec	3 msec	1 msec

R-1(config)#interface s0/0

R-1(config-if)#no shutdown

R-1(config-if)#end

R-1#sh ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface
192.168.2.100	0	FULL/ -	00:00:38	10.0.0.2	Serial0/0
192.168.3.100	0	FULL/ -	00:00:32	12.0.0.2	Serial0/1

R-1#sh ip route ospf

- 11.0.0.0 [110/128] via 12.0.0.2, 00:00:26, Serial0/1
- [110/128] via 10.0.0.2, 00:00:26, Serial0/0
- 192.168.2.0 [110/65] via 10.0.0.2, 00:00:26, Serial0/0
- IA 192.168.3.0 [110/65] via 12.0.0.2, 00:04:21, Serial0/1

R-1#traceroute 192.168.3.1

Type escape sequence to abort.

Tracing the route to 192.168.3.1

1	12.0.0.2	2 msec	1 msec	31 msec
2	192.168.3.1	12 msec	1 msec	1 msec

R-1#traceroute 192.168.2.1

Type escape sequence to abort.

Tracing the route to 192.168.2.1

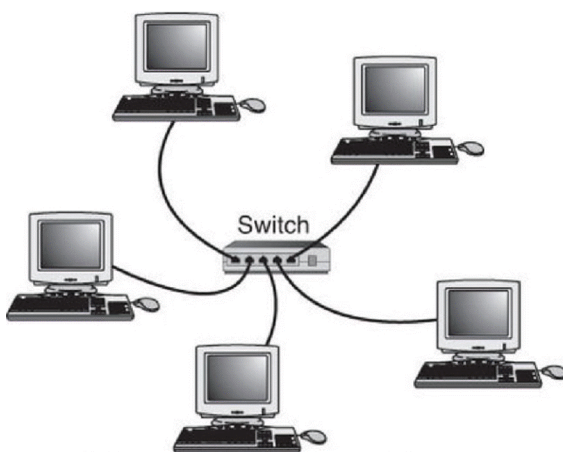
1	10.0.0.2	39 msec	0 msec	0 msec
2	192.168.2.1	0 msec	1 msec	0 msec



Basic Switching Concepts

Cisco Switch

Provides centralized location to connect devices with in the LAN.

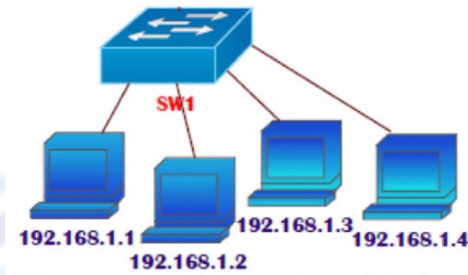


Switch



Rj45 Cable

Basic LAN setup



- ▶ Connect 4 computers in the LAN using Switch
- ▶ Configure IP addressing on all PC using 192.168.1.0/24 network.
- ▶ Check Connectivity between all the PC using Ping command

Hub	Switch
1. It has no intelligence. 2. It always do broadcasts 3. It works with 0's and 1's (Bits) 4. It has 1 Broadcast Domain 5. It has 1 Collision Domain. 6. It works with shared bandwidth	1. Its is An Intelligent device & maintains a MAC address table. 2. It uses broadcast and Unicast 3. It works with Physical addresses (i.e. MAC addresses) 4. It has 1 Broadcast domain by default 5. Number of Collision domains depends upon the number of ports. 6. It works with fixed bandwidth

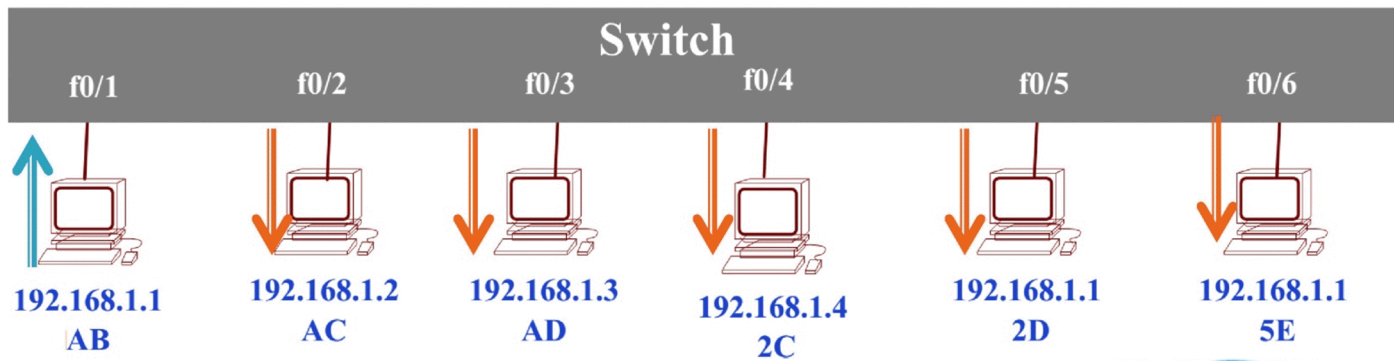
ARP process

Switch identify devices based on Mac-address

S – 192.168.1.1
D - 192.168.1.4

S – MAC=AB
D - MAC= ?

ARP Request
192.168.1.4 MAC= ?



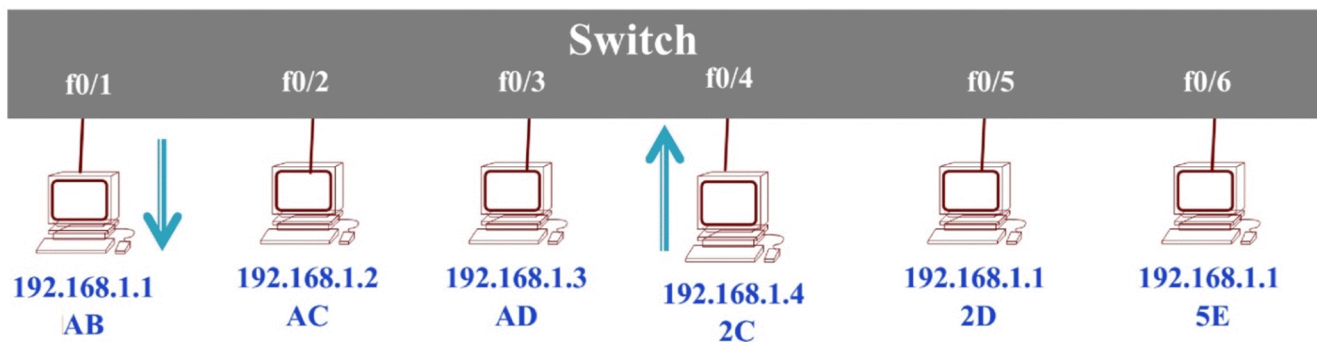
ARP process

Switch identify devices based on Mac-address

S – 192.168.1.1
D - 192.168.1.4

S – MAC=AB
D - MAC= ?

ARP reply
192.168.1.4 = 2C

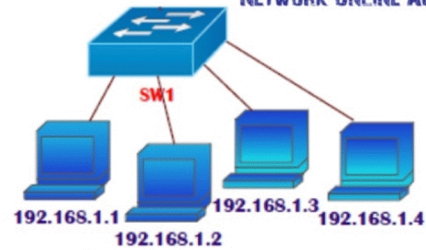


ARP verification

PC>ping 192.168.1.2

Pinging 192.168.1.2 with 32 bytes of data:

Reply from 192.168.1.2: bytes=32 time=1ms TTL=128
Reply from 192.168.1.2: bytes=32 time=0ms TTL=128
Reply from 192.168.1.2: bytes=32 time=0ms TTL=128
Reply from 192.168.1.2: bytes=32 time=0ms TTL=128



PC>ping 192.168.1.3

Pinging 192.168.1.3 with 32 bytes of data:

Reply from 192.168.1.3: bytes=32 time=2ms TTL=128
Reply from 192.168.1.3: bytes=32 time=0ms TTL=128
Reply from 192.168.1.3: bytes=32 time=0ms TTL=128
Reply from 192.168.1.3: bytes=32 time=0ms TTL=128

PC>arp -a

Internet Address	Physical Address	Type
192.168.1.2	000c.8547.85b2	dynamic
192.168.1.3	0060.5c31.6aeb	dynamic

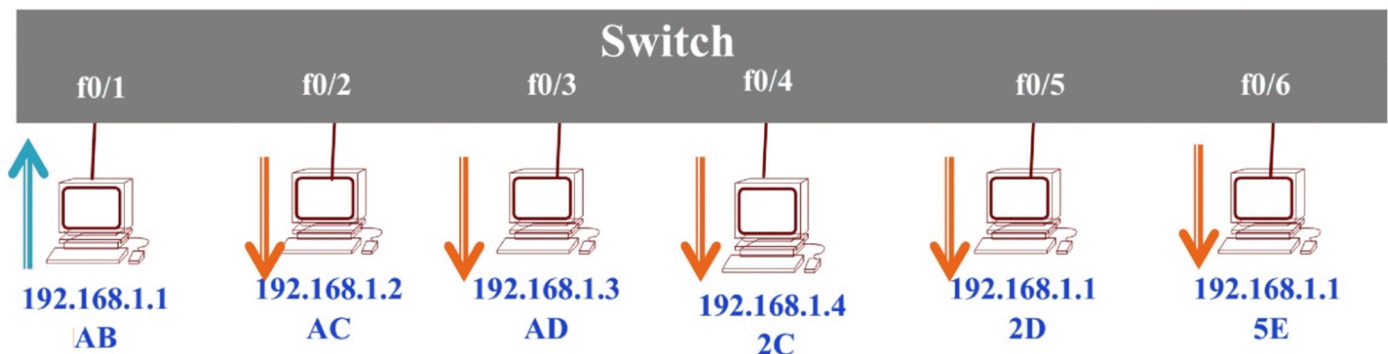
How switch Learn MAC address

MAC-table Entries

Port	MAC
f0/1	AB

S – 192.168.1.1 - AB
D - 192.168.1.4 - 2C

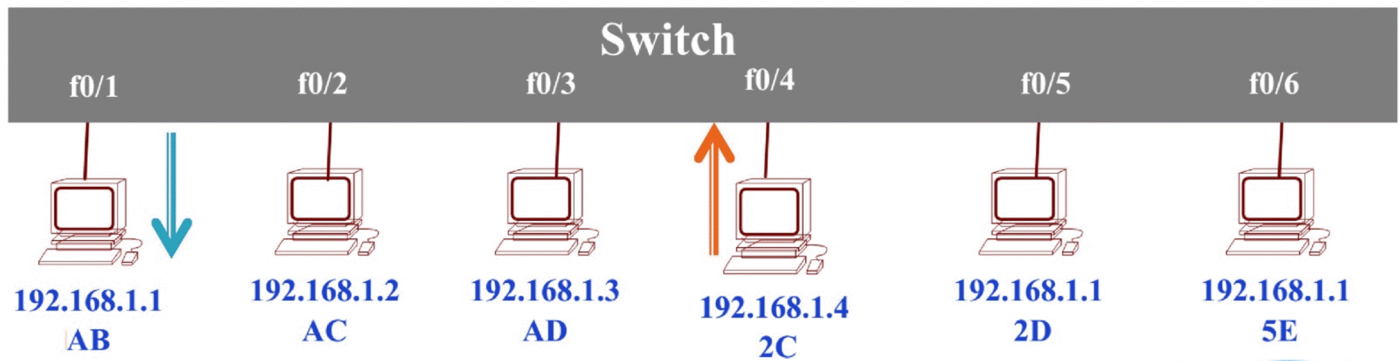
S - AB -- f0/1
D - 2C -- ?



How switch Learn MAC address

S - 2C – f0/4
D -AB – f0/1

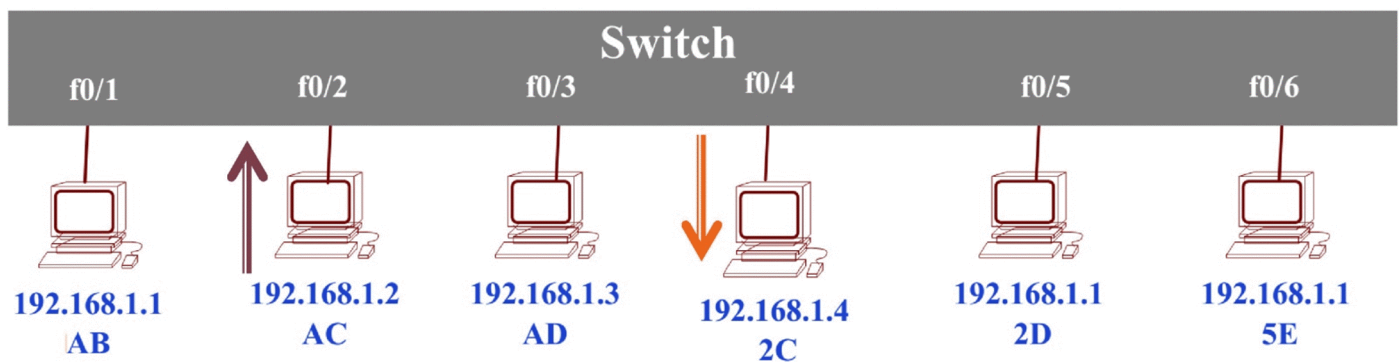
Port	MAC
F0/1	AB
F0/4	2C



How switch Learn MAC address

S - 192.168.1.2 AC
D -192.168.1.4 2C

Port	MAC
F0/1	AB
F0/4	2C
F0/2	AC



MAC-table verification

PC>ping 192.168.1.2

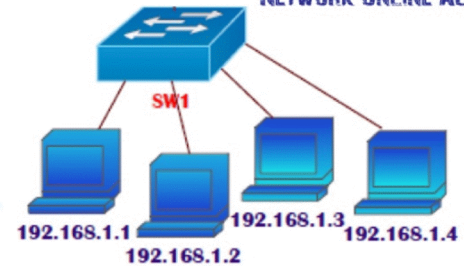
Pinging 192.168.1.2 with 32 bytes of data:

Reply from 192.168.1.2: bytes=32 time=0ms TTL=128

Reply from 192.168.1.2: bytes=32 time=0ms TTL=128

Reply from 192.168.1.2: bytes=32 time=0ms TTL=128

Reply from 192.168.1.2: bytes=32 time=0ms TTL=128



PC>ping 192.168.1.3

Pinging 192.168.1.3 with 32 bytes of data:

Reply from 192.168.1.3: bytes=32 time=1ms TTL=128

Reply from 192.168.1.3: bytes=32 time=0ms TTL=128

Reply from 192.168.1.3: bytes=32 time=0ms TTL=128

Reply from 192.168.1.3: bytes=32 time=0ms TTL=128

MAC-table verification

PC>ping 192.168.1.4

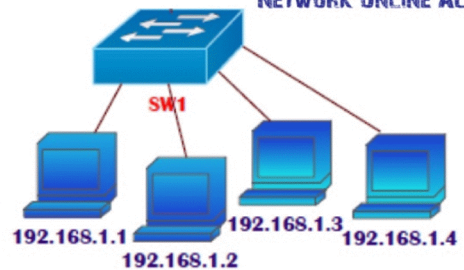
Pinging 192.168.1.4 with 32 bytes of data:

Reply from 192.168.1.4: bytes=32 time=1ms TTL=128

Reply from 192.168.1.4: bytes=32 time=1ms TTL=128

Reply from 192.168.1.4: bytes=32 time=0ms TTL=128

Reply from 192.168.1.4: bytes=32 time=0ms TTL=128



Switch>sh mac-address-table

Mac Address Table

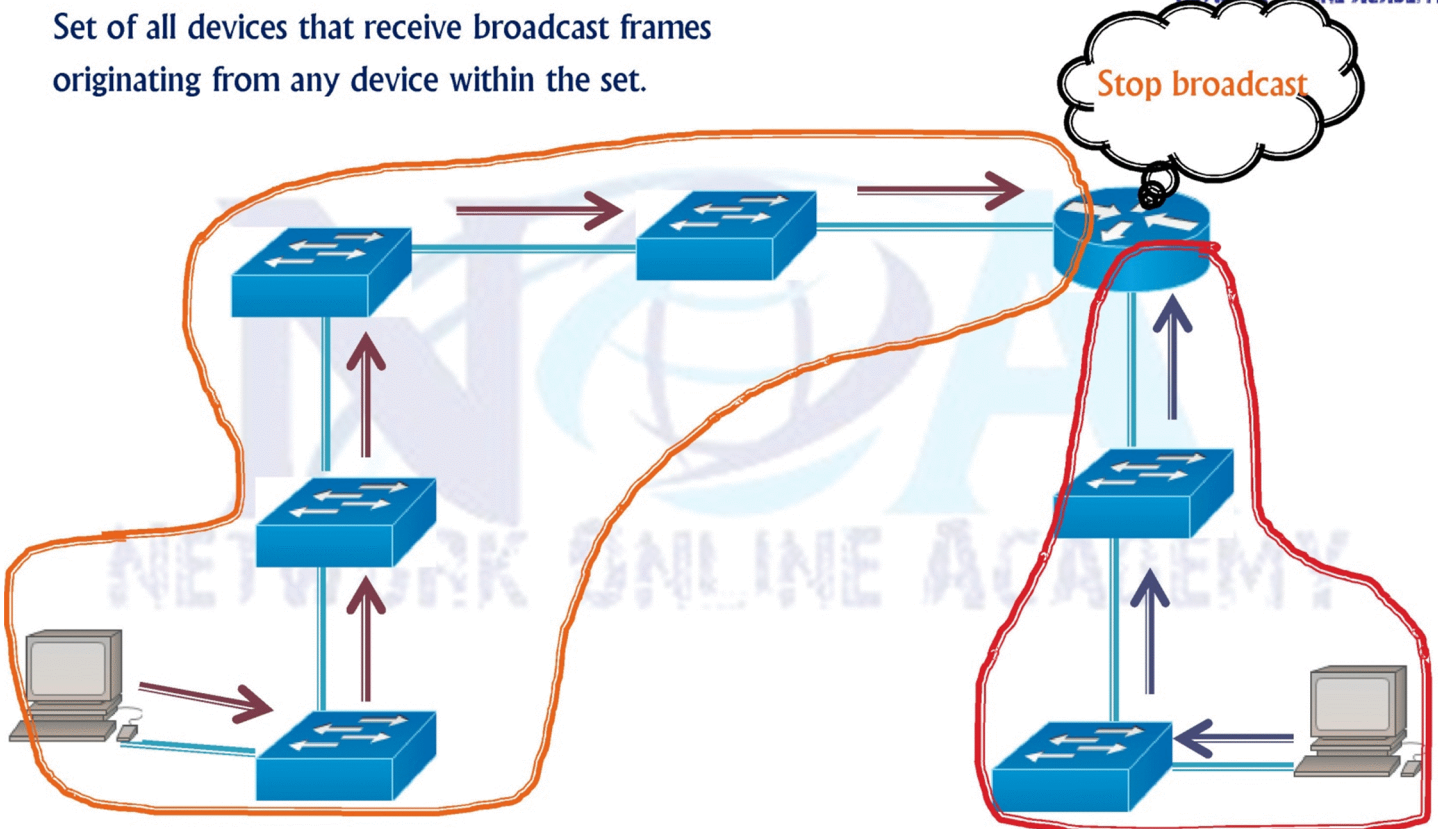
Vlan	Mac Address	Type	Ports
1	000a.419b.8ca9	DYNAMIC	Fa0/5
1	000c.8547.85b2	DYNAMIC	Fa0/2
1	0060.5c31.6aeb	DYNAMIC	Fa0/4
1	00d0.ff8b.4dad	DYNAMIC	Fa0/1

Switch basic functions

- ▶ If destination address present in mac-table - Switch do unicast
- ▶ If destination address not present in mac-table - Switch do broadcast (flooding)
- ▶ Switches update the MAC-table based on source address .
- ▶ Max-age time for mac-entries is 300 seconds of inactivity.

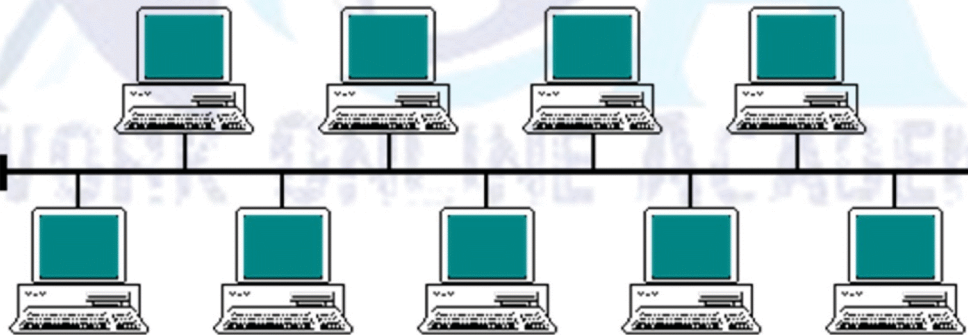
Broadcast Domain

Set of all devices that receive broadcast frames originating from any device within the set.

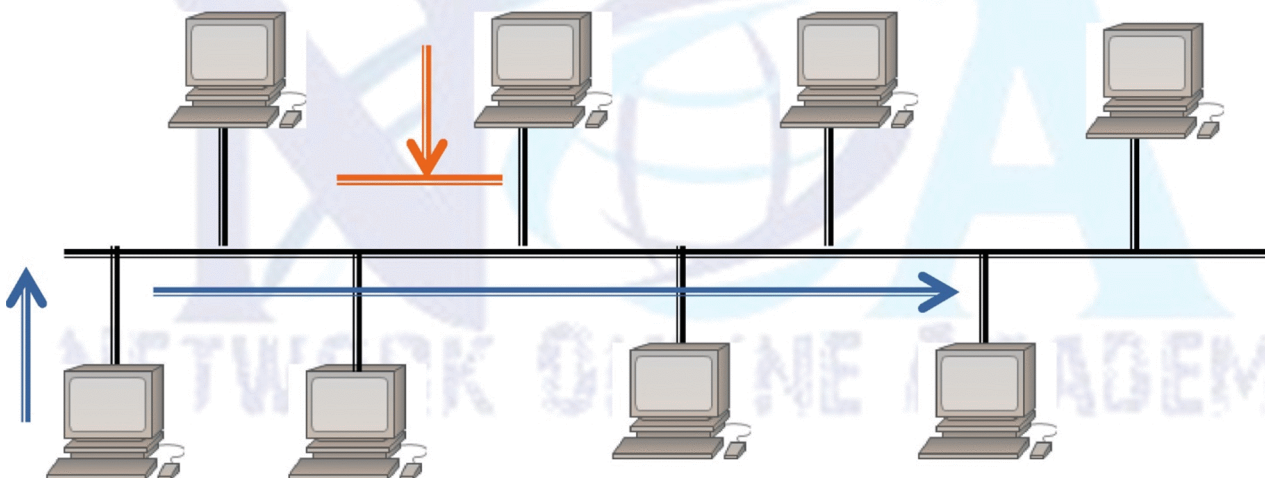


CSMA/CD

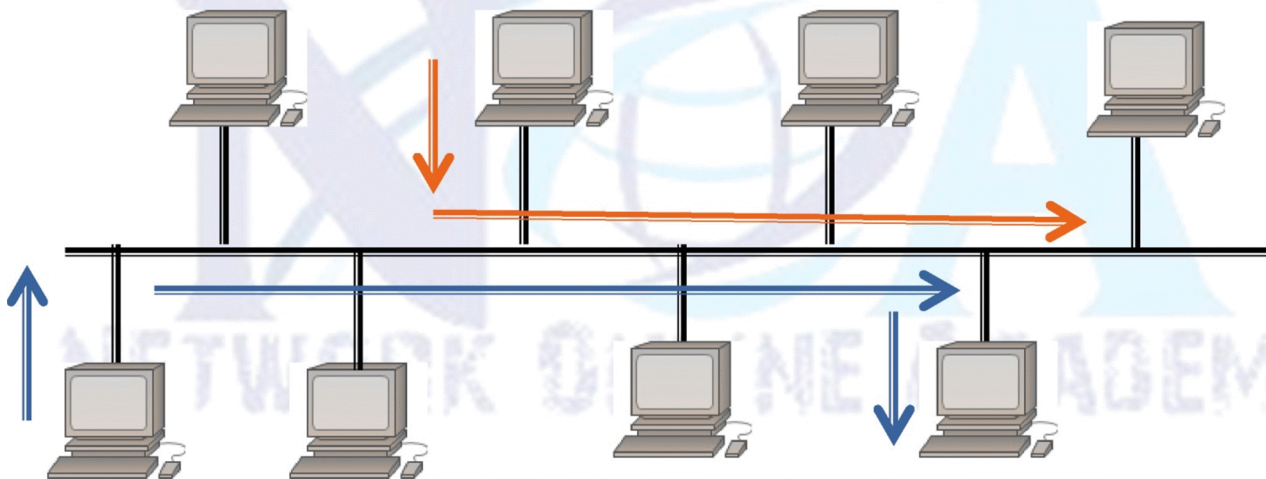
- ▶ Carrier sense Multiple access / Collision detection
- ▶ Protocol for carrier transmission access in Ethernet networks.
- ▶ Collisions are identified using CSMA/CD
- ▶ CSMA/CD works in Wired LAN
- ▶ CSMA/CA works in Wireless LAN



Carrier sense Multiple Access / Collision detection



Carrier sense Multiple Access / Collision detection



Collision Domain

A collision domain is a network segment with two or more devices sharing the same bandwidth. (where there is a chance of collision)

Hubs

- shared bandwidth
- one collision domain.

Switches

- dedicated bandwidth
- collision domain depends on number of ports

Types of Switches

Unmanageable switches

- plug and play (Connect & use)
- No configurations and verifications can be done
- There is no console port.



Manageable switches

- also plug and play (Connect & use)
- It has console port and CLI access.
- We can verify and modify configurations and can implement and test some advance switching technologies (VLAN, trunking , STP)



Cisco's Hierarchical Design Model

Access Layer

1900 & 2900 (L2 switches)

Catalyst 2900



Catalyst 1900



Distribution Layer

3550, 3560, 3750

(L3 switches or multi-layer switches)

Cisco 3550



Cisco 3560



Cisco's Hierarchical Design Model

Core Layer

4500, 6500 (L3 switches or multi-layer switches)

4500 , 6500



Initial configuration of a switch:

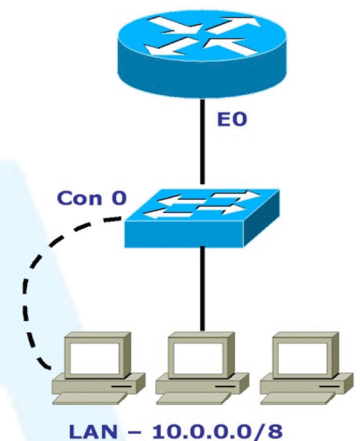
Console Connectivity (PC – Switch)



RJ45

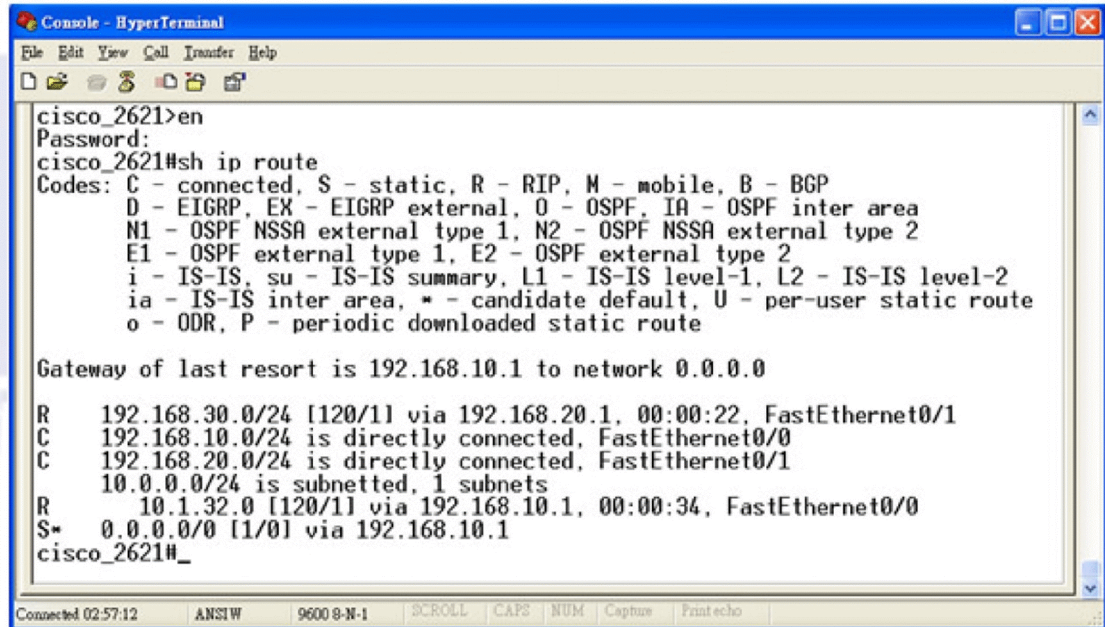
RS232

Console Cable



Initial configuration of a switch:

Emulation Software (Hyper-terminal, putty, Secure CRT)



```
cisco_2621>en
Password:
cisco_2621#sh ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
        D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
        N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
        E1 - OSPF external type 1, E2 - OSPF external type 2
        i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
        ia - IS-IS inter area, * - candidate default, U - per-user static route
        o - ODR, P - periodic downloaded static route

Gateway of last resort is 192.168.10.1 to network 0.0.0.0

R    192.168.30.0/24 [120/1] via 192.168.20.1, 00:00:22, FastEthernet0/1
C    192.168.10.0/24 is directly connected, FastEthernet0/0
C    192.168.20.0/24 is directly connected, FastEthernet0/1
     10.0.0.0/24 is subnetted, 1 subnets
R       10.1.32.0 [120/1] via 192.168.10.1, 00:00:34, FastEthernet0/0
S*    0.0.0.0/0 [1/0] via 192.168.10.1
cisco_2621#
```

Modes on Cisco Switches

User Mode:	Only some basic monitoring	Switch>
Privileged Mode:-	monitoring and some troubleshooting	Switch#
Global Configuration mode:-	All Configurations that effect the switch globally	Switch(config)#
Interface mode:-	Configurations done on the specific interface	Switch(config-if)#

Switch>show flash

Directory of flash:/

```
1 -rw- 4414921 <no date> c2960-lanbase-mz.122-25.FX.bin
64016384 bytes total (59601463 bytes free)
```

Switch>show version

Cisco IOS Software, C2960 Software (C2960-LANBASE-M), Version 12.2(25)FX, RELEASE SOFTWARE (fc1)
 Copyright (c) 1986-2005 by Cisco Systems, Inc.
 Compiled Wed 12-Oct-05 22:05 by pt_team
 ROM: C2960 Boot Loader (C2960-HBOOT-M) Version 12.2(25r)FX, RELEASE SOFTWARE (fc4)
 System returned to ROM by power-on
 Cisco WS-C2960-24TT (RC32300) processor (revision Co) with 21039K bytes of memory.
 24 FastEthernet/IEEE 802.3 interface(s)
 2 Gigabit Ethernet/IEEE 802.3 interface(s)
 63488K bytes of flash-simulated non-volatile configuration memory.

(Some output is on the next page)

Base ethernet MAC Address : 00E0.8F66.9415
 Motherboard assembly number : 73-9832-06
 Power supply part number : 341-0097-02
 Motherboard serial number : FOC103248M]
 Power supply serial number : DCA102133]A
 Model revision number : B0
 Motherboard revision number : C0
 Model number : WS-C2960-24TT
 System serial number : FOC1033Z1EY
 Top Assembly Part Number : 800-26671-02
 Top Assembly Revision Number : B0
 Version ID : V02
 CLEI Code Number : COM3K00BRA
 Hardware Board Revision Number : 0x01

Switch	Ports	Model	SW Version	SW Image
* 1	26	WS-C2960-24TT	12.2	C2960-LANBASE-M

Configuration register is 0xF

Switch>show ip interface brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/1	unassigned	YES	manual	down	down
FastEthernet0/2	unassigned	YES	manual	down	down
FastEthernet0/3	unassigned	YES	manual	down	down
.....					
.....					
.....					
FastEthernet0/23	unassigned	YES	manual	down	down
FastEthernet0/24	unassigned	YES	manual	down	down
GigabitEthernet1/1	unassigned	YES	manual	down	down
GigabitEthernet1/2	unassigned	YES	manual	down	down
Vlan1	unassigned	YES	manual	administratively down	down

Switch> ping 1.1.1.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 1.1.1.1, timeout is 2 seconds:

.....

Success rate is 0 percent (0/3)

Switch > traceroute 1.1.1.1

Type escape sequence to abort.

Tracing the route to 1.1.1.1

Privilege Mode

- Complete monitoring
- All show commands, Copy , erase commands

Switch #

Switch> **enable**

Switch #

Switch # **show flash**

Switch # **show version**

Switch # **show ip interface brief**

Switch# **ping 1.1.1.1**

Switch # **traceroute 50.1.1.1**

Switch # **show running-config**

(configs in RAM)

Switch # **show startup-config**

(configs in NVRAM)

Switch # **Copy**

(save configurations)

Switch # **erase**

(erase configurations)

SW1#sh interfaces status

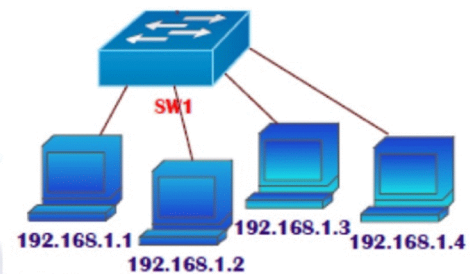
Port	Name	Status	Vlan	Duplex	Speed	Type
Fa1/0		notconnect	1	auto	auto	10/100BaseTX
Fa1/1		connected	trunk	full	100	10/100BaseTX
Fa1/2		connected	trunk	full	100	10/100BaseTX
Fa1/3		connected	trunk	full	100	10/100BaseTX
Fa1/4		connected	trunk	full	100	10/100BaseTX
Fa1/5		connected	15	full	100	10/100BaseTX
Fa1/6		connected	16	full	100	10/100BaseTX
Fa1/7		connected	11	full	100	10/100BaseTX
Fa1/8		connected	18	full	100	10/100BaseTX
Fa1/9		notconnect	19	auto	auto	10/100BaseTX
Fa1/10		connected	19	full	100	10/100BaseTX
Fa1/11		connected	trunk	full	100	10/100BaseTX
Fa1/12		connected	trunk	full	100	10/100BaseTX
Fa1/13		connected	trunk	full	100	10/100BaseTX
Fa1/14		disabled	143	auto	auto	10/100BaseTX
Fa1/15		connected	21	full	100	10/100BaseTX

To check the mac-address entries in the MAC table

Switch# show mac-address-table

Mac Address Table

Vlan	Mac Address	Type	Ports
1	000a.419b.8ca9	DYNAMIC	Fa0/5
1	000c.8547.85b2	DYNAMIC	Fa0/2
1	0060.5c31.6aeb	DYNAMIC	Fa0/4
1	00d0.ff8b.4dad	DYNAMIC	Fa0/1



Changing Hostnames

Without names, network devices are difficult to identify for configuration purposes.

Configuring Device Names

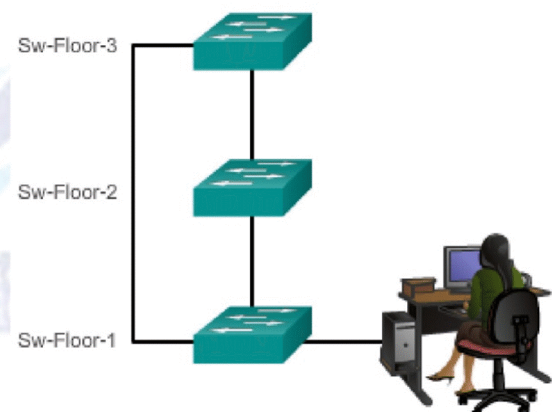
Switch #

Switch # configure terminal

Switch (config) #

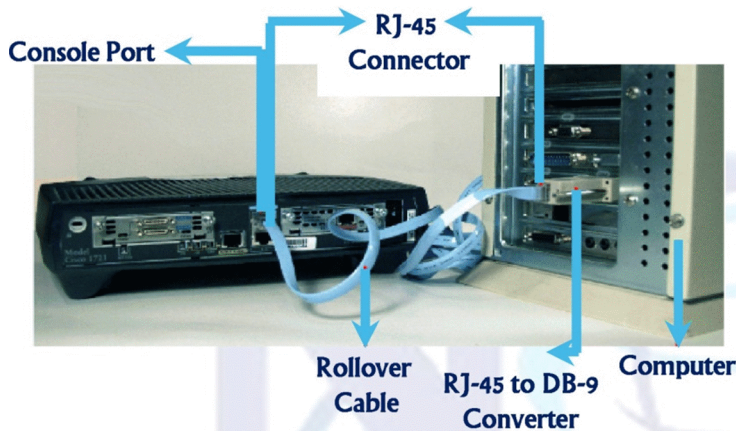
Switch (config) # hostname SW-1

SW-1 (config) #

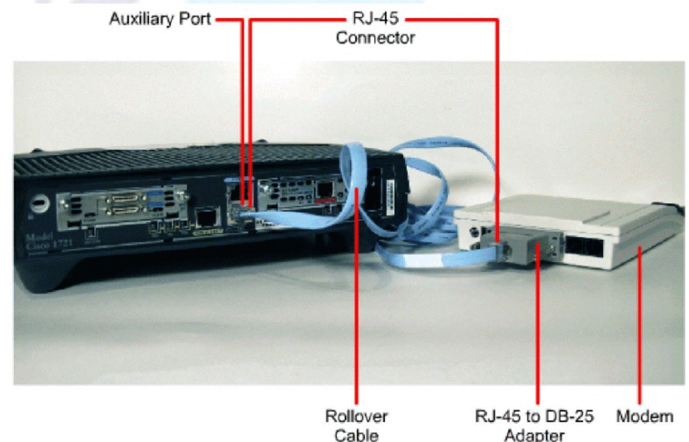


Hostnames allow devices to be identified by network administrators over a network

Assigning Passwords



- ▶ Console
- ▶ Auxiliary
- ▶ VTY line (telnet)



Assigning console password:

```
Switch(config) # line con 0
Switch(config-line) # password <password> (line mode)
Switch(config-line) # login
Switch(config-line) # exit
```

Assigning Auxiliary password:

```
Switch(config) # line aux 0
Switch(config-line) # password <password> (line mode)
Switch(config-line) # login
Switch(config-line) # exit
```

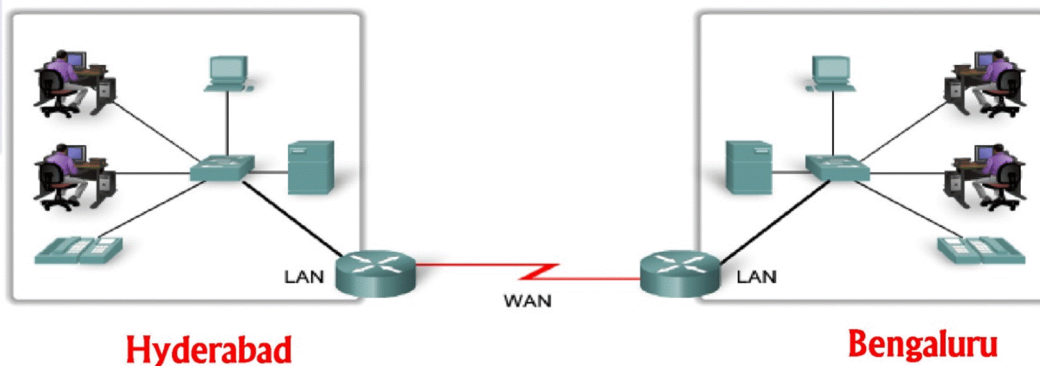
Assigning Telnet password:

Switch(config) # **line vty 0 4**

Switch(config-line) # **password <password>** (line mode)

Switch(config-line) # **login**

Switch(config-line) # **exit**



Initial configuration of Switch for telnet Access

Switches can be configured with IP address for remote access

To assign IP to a Switch

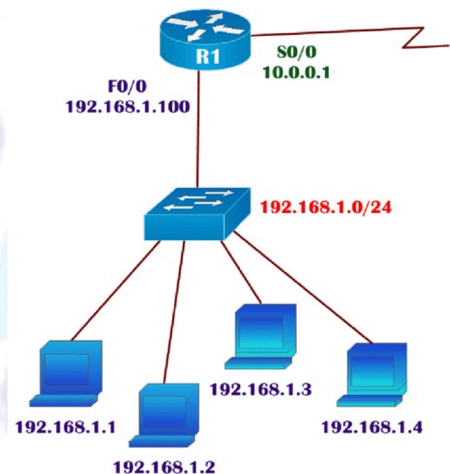
switch(config)# **Interface Vlan 1**

switch(config-if)# **ip address <ip> <mask>**

switch(config-if)# **no shutdown**

To assign Default Gateway to a Switch

switch(config)# **ip default-gateway 192.168.1.100**




```
Switch(config)#interface vlan 1
Switch(config-if)#ip address 192.168.1.50 255.255.255.0
Switch(config-if)#no shutdown
Switch(config-if)#exit
```

```
Switch(config)#ip default-gateway 192.168.1.100
```

```
PC>ping 192.168.1.50
```

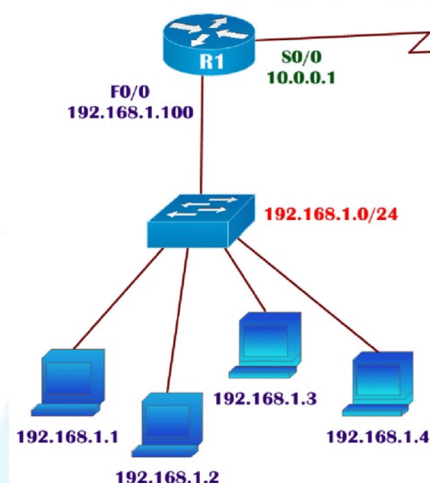
Pinging 192.168.1.50 with 32 bytes of data:

Request timed out.

Reply from 192.168.1.50: bytes=32 time=0ms TTL=255

Reply from 192.168.1.50: bytes=32 time=0ms TTL=255

Reply from 192.168.1.50: bytes=32 time=0ms TTL=255



Verify Telnet Access on Switch

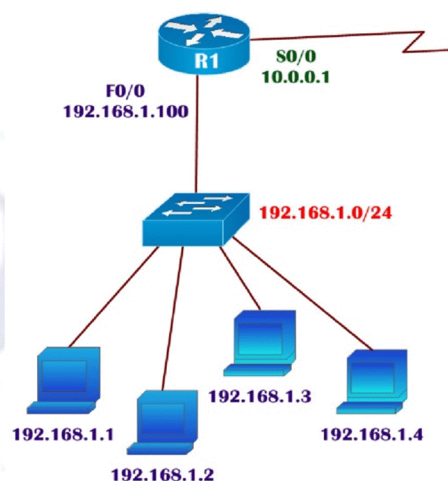
```
Switch(config)#line vty 0 4
Switch(config-line)#password noa123
Switch(config-line)#login
```

```
PC>telnet 192.168.1.50
```

Trying 192.168.1.50 ...Open
User Access Verification

Password:

```
Switch>exit
```



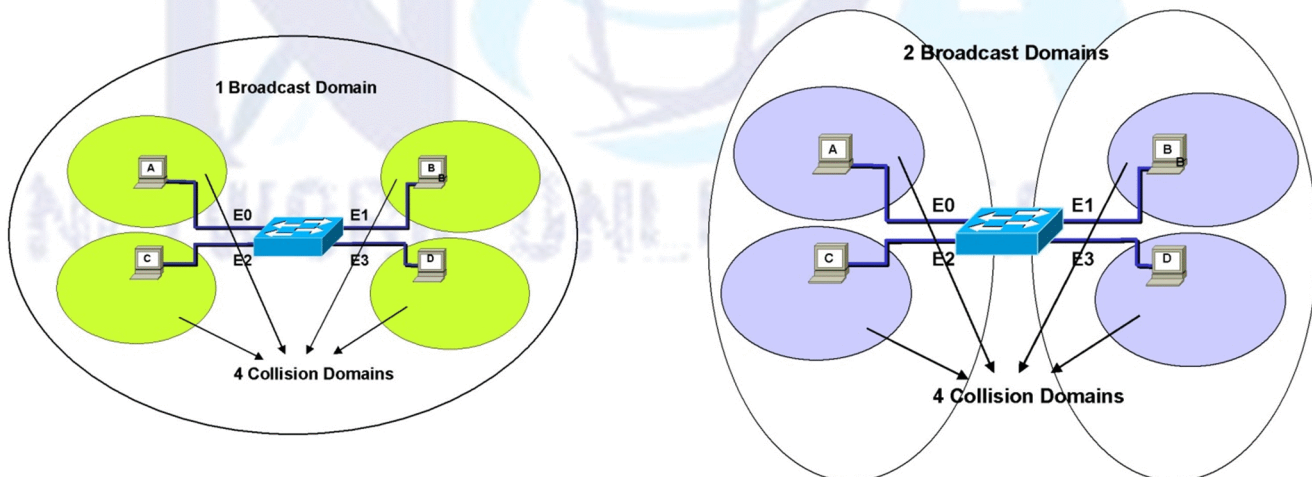
[Connection to 192.168.1.50 closed by foreign host]

```
PC>
```


VLAN & Trunks

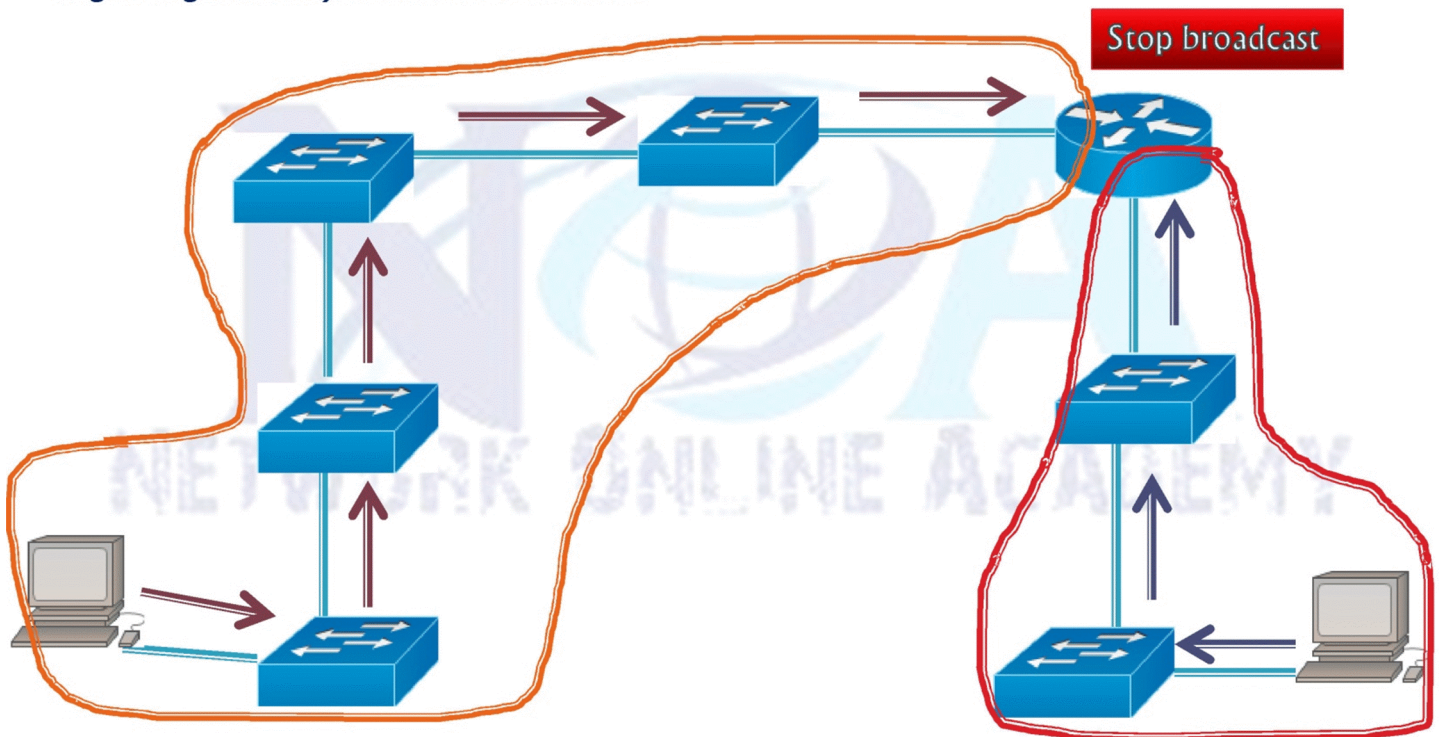
Virtual LAN

- ▶ Divides one single Broadcast domain into Multiple Broadcast domains.
- ▶ Layer 2 Security
- ▶ Vlan 1 is the default VLAN.
- ▶ We can create vlans from 2 – 1001
- ▶ Can be Configured on a Manageable switches only



Broadcast Domain

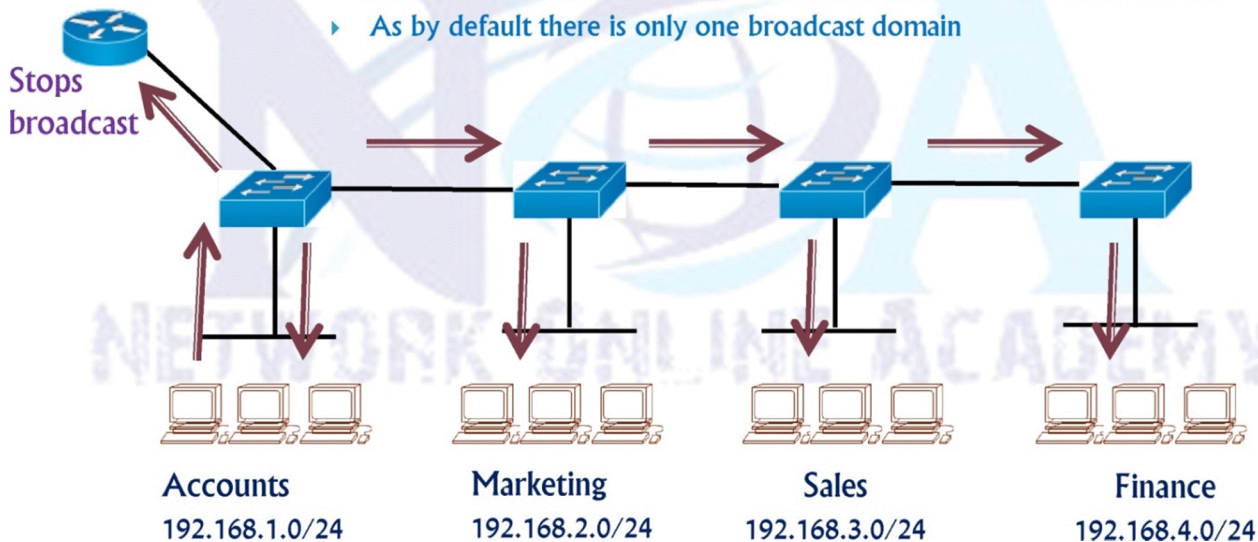
Set of all devices that receive broadcast frames originating from any device within the set.



What happens when a computer connected to the Accounts department

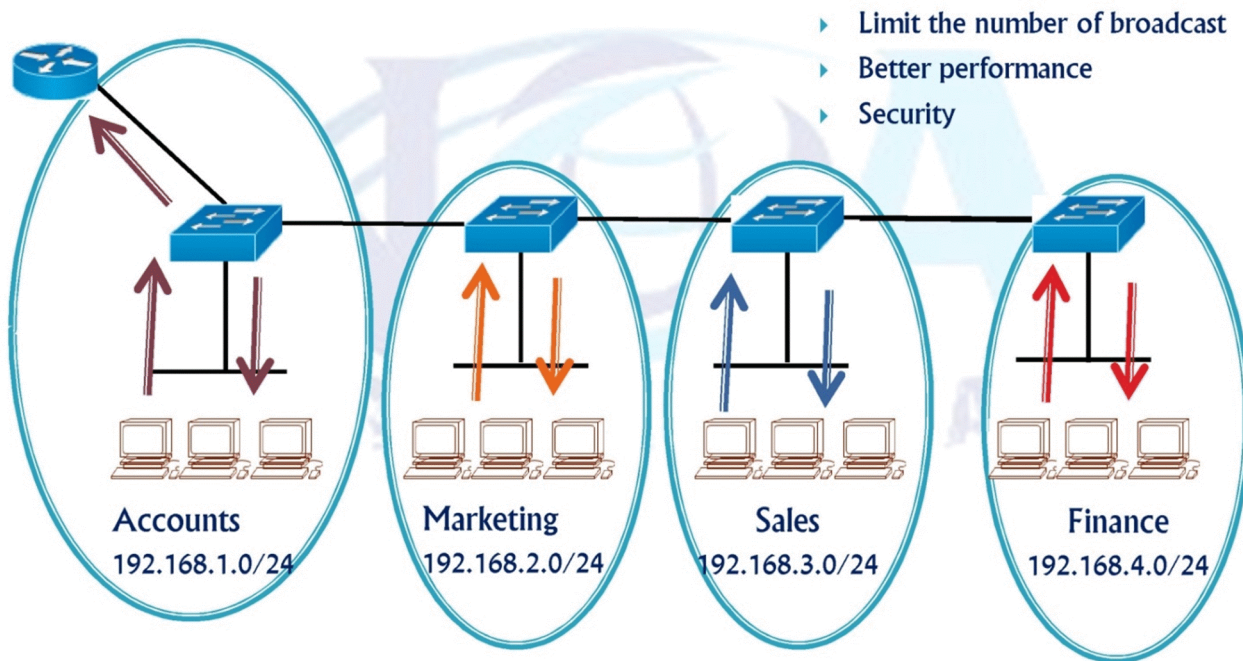
- sends a broadcast like an ARP request?
- Or if the destination mac unknown (not present in mac-table)

- ▶ By default the broadcast goes to each and every device in the network.
- ▶ As by default there is only one broadcast domain



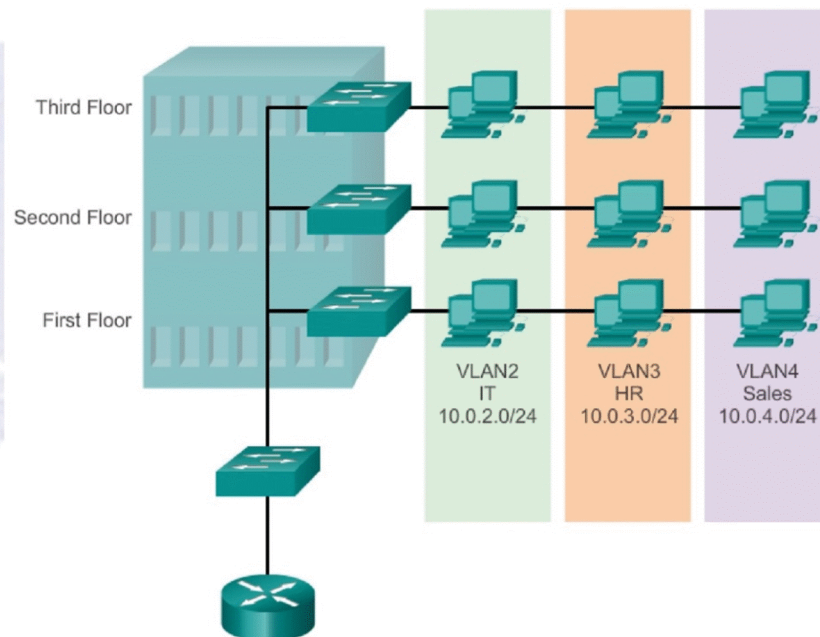
- ▶ By default the broadcast goes to each and every device in the network.
- ▶ As by default there is only one broadcast domain

VLAN divides one single broadcast domain in to multiple Broadcast domains



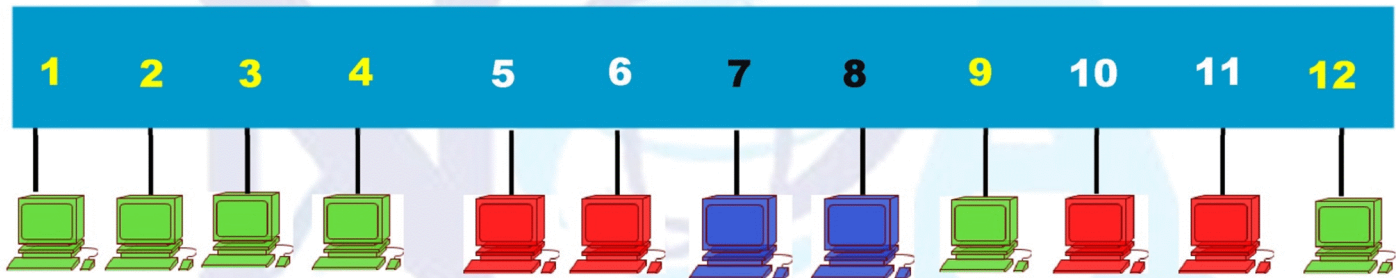
Benefits of VLANs

- ▶ Limit the number of broadcast
- ▶ Better performance
- ▶ Security



VLAN

- ▶ Work based on port numbers
- ▶ Default all ports will be in vlan 1
- ▶ Need to manually assign a port on a switch to a VLAN
- ▶ One port can be a member of only one VLAN



vlan 10 (Green) = 1, 2, 3, 4, 9 , 12
 vlan 20 (Red) = 5, 6, 10, 11
 vlan 30 (Blue) = 7 , 8

Switch#show vlan brief

VLAN Name	Status	Ports
1 default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Fa0/11, Fa0/12 Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18, Fa0/19, Fa0/20 Fa0/21, Fa0/22, Fa0/23, Fa0/24
1002 fddi-default	active	
1003 token-ring-default	active	
1004 fddinet-default	active	
1005 trnet-default	active	

Creating VLAN

```
Switch(config)# vlan <no>
Switch(config-Vlan)# name <name>
Switch(config-Vlan)# Exit
```

Switch#sh vlan brief

```
Switch(config)#vlan 10
```

```
Switch(config-vlan)#name Green
```

```
Switch(config-vlan)#vlan 20
```

```
Switch(config-vlan)#name Red
```

```
Switch(config-vlan)#vlan 30
```

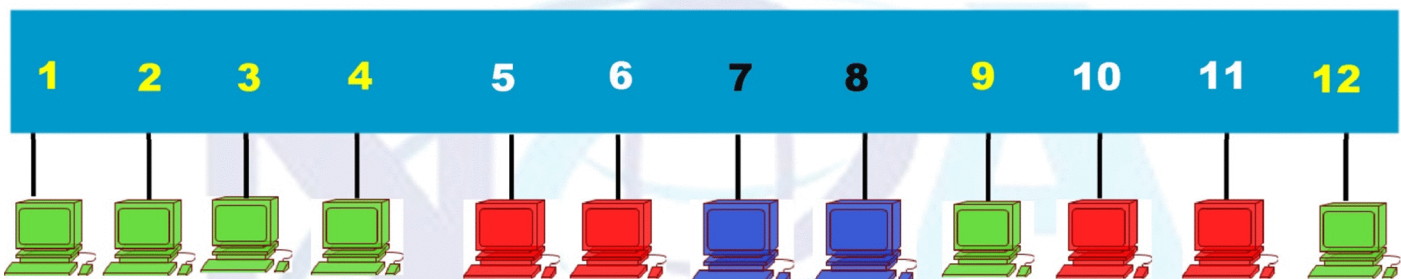
```
Switch(config-vlan)#name Blue
```

```
Switch(config-vlan)#end
```

VLAN Name	Status	Ports
1 default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Fa0/11, Fa0/12 Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18, Fa0/19, Fa0/20 Fa0/21, Fa0/22, Fa0/23, Fa0/24
10 Green	active	
20 Red	active	
30 Blue	active	
1002 fddi-default	active	
1003 token-ring-default	active	
1004 fddinet-default	active	
1005 trnet-default	active	

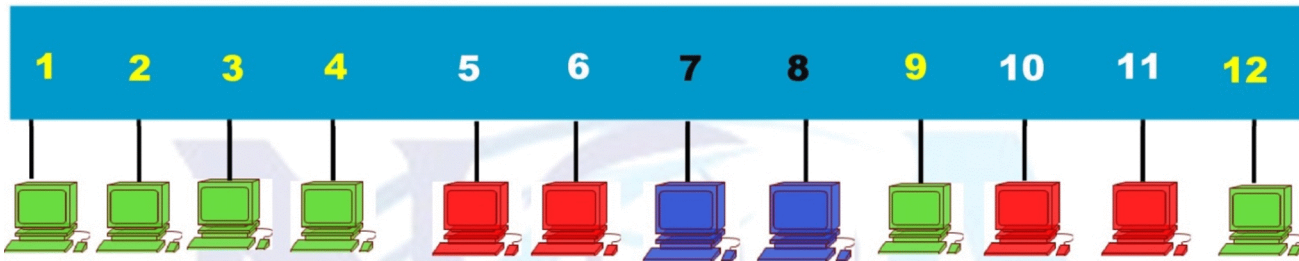
Assigning ports - VLAN

```
Switch(config)# interface <interface type> <interface no.>
Switch(config-if)# switchport mode access
Switch(config-if)# switchport access Vlan <no>
```



```
Switch(config)#interface range f0/1 - 4 , f0/9 , f0/12
Switch(config-if-range)#switchport mode access
Switch(config-if-range)#switchport access vlan 10
Switch(config-if-range)#exit
```

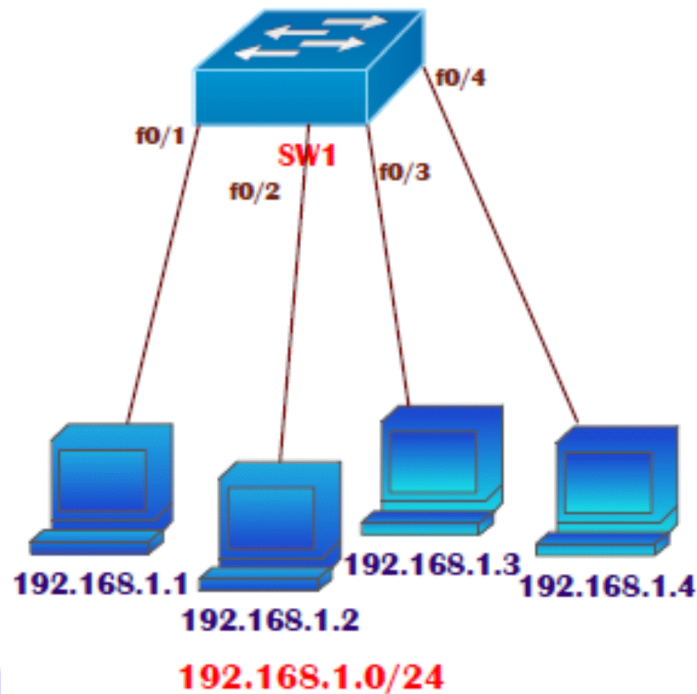

Assigning ports - VLAN



```
Switch(config)#interface range f0/5 - 6 , f0/10 - 11
Switch(config-if-range)#switchport mode access
Switch(config-if-range)#switchport access vlan 20
Switch(config-if-range)#exit
```

```
Switch(config)#int range f0/7 - 8
Switch(config-if-range)#switchport mode access
Switch(config-if-range)#switchport access vlan 30
Switch(config-if-range)#exit
```


LAB –Verify VLAN



STEPS:

1. Ping between 192.168.1.1 and 192.168.1.3
 - a. (they can communicate with each other and they are on the same network (logically) and same VLAN (default vlan 1)
2. Create VLAN 20
3. Shift port f0/3 , f0/4 in to VLAN 20
4. Ping between 192.168.1.1 and 192.168.1.3
 - a. they cannot communicate with each other and they are on the same network (logically) but on different VLAN (VLAN1 and vlan 20)

Switch#sh vlan

VLAN Name	Status	Ports
1 default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Fa0/11, Fa0/12 Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18, Fa0/19, Fa0/20 Fa0/21, Fa0/22, Fa0/23, Fa0/24 Gig1/1, Gig1/2
1002 fddi-default	act/unsup	
1003 token-ring-default	act/unsup	
1004 fddinet-default	act/unsup	
1005 trnet-default	act/unsup	

PC>ipconfig

IP Address.....: 192.168.1.1
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 192.168.1.100

PC>ping 192.168.1.2

Pinging 192.168.1.2 with 32 bytes of data:
Reply from 192.168.1.2: bytes=32 time=19ms TTL=128
Reply from 192.168.1.2: bytes=32 time=6ms TTL=128
Reply from 192.168.1.2: bytes=32 time=8ms TTL=128
Reply from 192.168.1.2: bytes=32 time=7ms TTL=128

PC>ping 192.168.1.3

Pinging 192.168.1.3 with 32 bytes of data:
Reply from 192.168.1.3: bytes=32 time=12ms TTL=128
Reply from 192.168.1.3: bytes=32 time=9ms TTL=128
Reply from 192.168.1.3: bytes=32 time=7ms TTL=128
Reply from 192.168.1.3: bytes=32 time=8ms TTL=128

PC>ping 192.168.1.4

Pinging 192.168.1.4 with 32 bytes of data:
Reply from 192.168.1.4: bytes=32 time=10ms TTL=128
Reply from 192.168.1.4: bytes=32 time=8ms TTL=128
Reply from 192.168.1.4: bytes=32 time=8ms TTL=128
Reply from 192.168.1.4: bytes=32 time=9ms TTL=128

All the Four devices in the LAN can communicate with each other and they are on the same network (logically) and same VLAN (default vlan 1)

TASK: Create Vlan 20 And Shift The Ports 3 And 4 In To Vlan 20

```
Switch(config)#vlan 20
Switch(config-vlan)#name SALES
Switch(config-vlan)#exit
```

```
Switch(config)#interface fastEthernet 0/3
Switch(config-if)#switchport mode access
Switch(config-if)#switchport access vlan 20
Switch(config-if)#exit
```

```
Switch(config)#interface fastEthernet 0/4
Switch(config-if)#switchport mode access
Switch(config-if)#switchport access vlan 20
```

Switch#sh vlan

VLAN Name	Status	Ports
1 default	active	Fa0/1, Fa0/2, Fa0/5, Fa0/6 Fa0/7, Fa0/8, Fa0/9, Fa0/10

Fa0/11, Fa0/12, Fa0/13, Fa0/14
Fa0/15, Fa0/16, Fa0/17, Fa0/18
Fa0/19, Fa0/20, Fa0/21, Fa0/22
Fa0/23, Fa0/24, Gig1/1, Gig1/2

20 SALES	active	Fa0/3, Fa0/4
1002 fddi-default	act/unsup	
1003 token-ring-default	act/unsup	
1004 fddinet-default	act/unsup	
1005 trnet-default	act/unsup	

PC>ipconfig

IP Address.....: 192.168.1.1
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 192.168.1.100

PC>ping 192.168.1.2

Pinging 192.168.1.2 with 32 bytes of data:
Reply from 192.168.1.2: bytes=32 time=11ms TTL=128
Reply from 192.168.1.2: bytes=32 time=9ms TTL=128
Reply from 192.168.1.2: bytes=32 time=7ms TTL=128
Reply from 192.168.1.2: bytes=32 time=7ms TTL=128

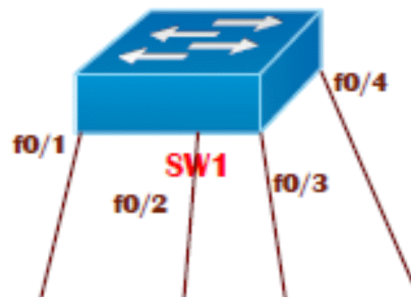
PC>ping 192.168.1.3

Pinging 192.168.1.3 with 32 bytes of data:
Request timed out.
Request timed out.
Request timed out.
Request timed out.

PC>ping 192.168.1.4

Pinging 192.168.1.4 with 32 bytes of data:
Request timed out.
Request timed out.
Request timed out.
Request timed out.

LAB -2 CREATING BASIC VLAN CONFIGURATION ON SWITCHES



TASK:

- Create four VLANs (VLAN 10,20,30,40)
- Configure port fa0/8 in to vlan 10
- Configure multiple ports (4 – 7 and 10) to vlan 20

```
Switch(config)#vlan 10
Switch(config-vlan)#name sales
```

```
Switch(config-vlan)#vlan 20
Switch(config-vlan)#name marketing
```

```
Switch(config-vlan)#vlan 30
Switch(config-vlan)#vlan 40
```

```
Switch(config-vlan)#end
```

```
Switch#sh vlan
```

VLAN Name	Status	Ports
1 default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Fa0/11, Fa0/12 Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18, Fa0/19, Fa0/20 Fa0/21, Fa0/22, Fa0/23, Fa0/24 Gig1/1, Gig1/2
10 sales	active	
20 marketing	active	
30 VLAN0030	active	
40 VLAN0040	active	

There are no active ports in the new vlan which we created

To shift the ports

```
Switch(config)#int f0/8
```

```
Switch(config-if)#switchport mode access
Switch(config-if)#switchport access vlan 10
Switch(config-if)#exit

Switch(config)#interface range f0/4 - 7 , f0/10
Switch(config-if-range)#switchport mode access
Switch(config-if-range)#switchport access vlan 20
```

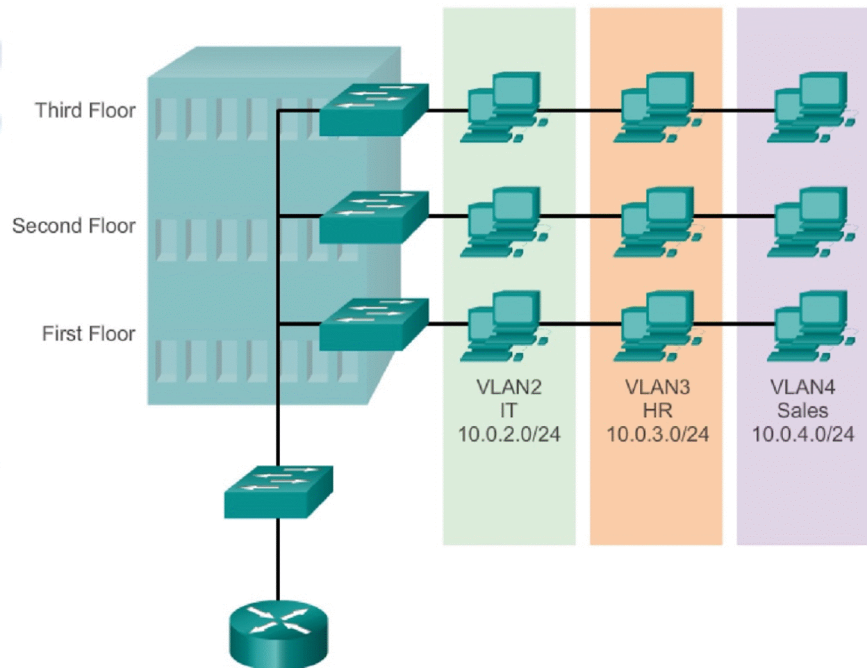
Switch#sh vlan

VLAN Name	Status	Ports
1 default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/9, Fa0/11, Fa0/12, Fa0/13 Fa0/14, Fa0/15, Fa0/16, Fa0/17 Fa0/18, Fa0/19, Fa0/20, Fa0/21 Fa0/22, Fa0/23, Fa0/24
10 sales	active	Fa0/8
20 marketing	active	Fa0/4, Fa0/5, Fa0/6, Fa0/7 Fa0/10

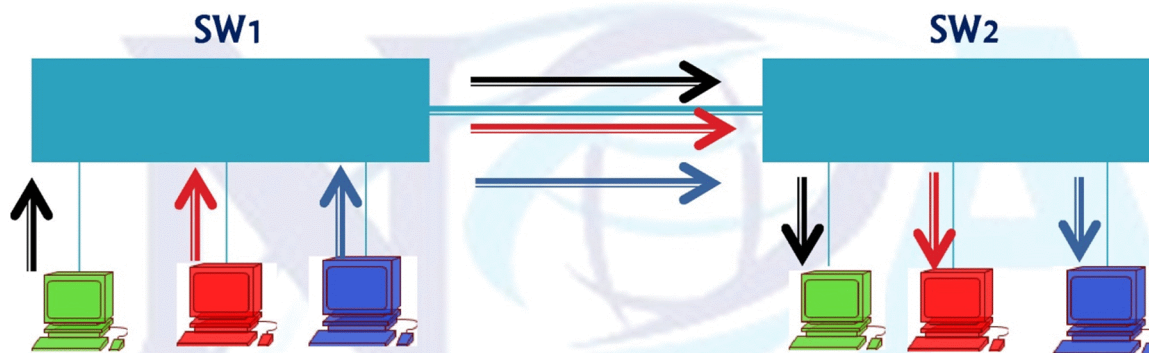


Trunking

- ▶ A single VLAN can span over Multiple Switches
- ▶ Users of the same VLAN – may connect on two or more switches with in the LAN



Passing same VLAN Traffic between switches using Single Link.



Types of links/ports

Access links

- ▶ Connecting to end devices (Hosts or router)
- ▶ part of one VLAN

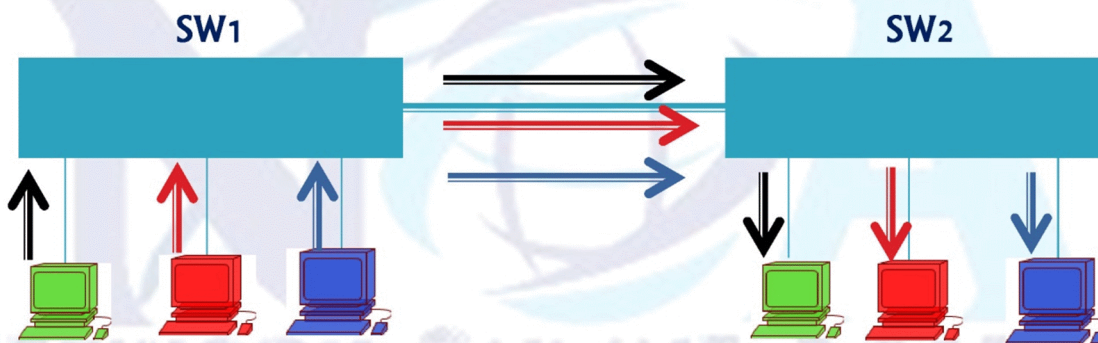
Trunk links

- ▶ Do not belong to any VLAN
- ▶ carry multiple VLANs traffic.
- ▶ link between two switches.



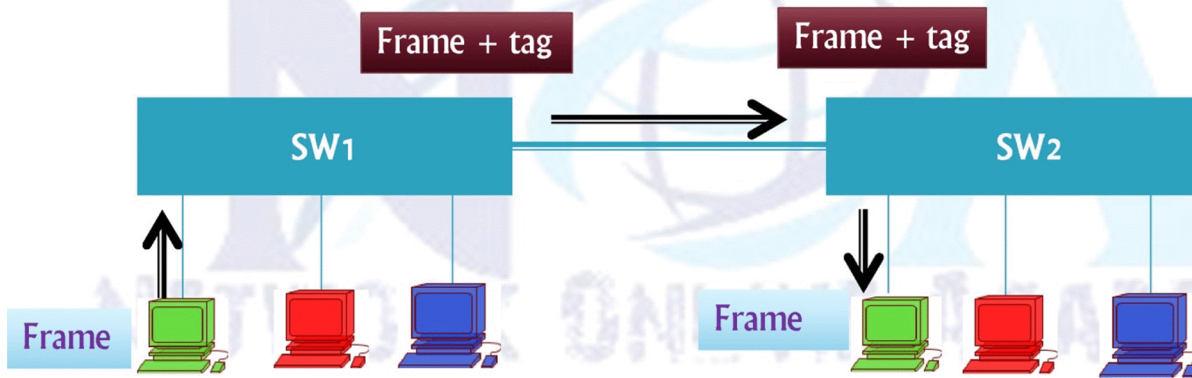
Frame Tagging

Passing same VLAN Traffic between switches using Single Link.



Frame Tagging

- ▶ In order to make sure that same VLAN users on different switches communicate with each other there is a method of tagging happens on trunk links .
- ▶ Tag is added before a frame is send and removed once it is received on trunk link.
- ▶ Frame tagging happens only on the trunk links



- Frame includes source and destination MAC entries
- Tag includes the VLAN- ID

Trunking protocols

Responsible for adding and removing tags on trunk links

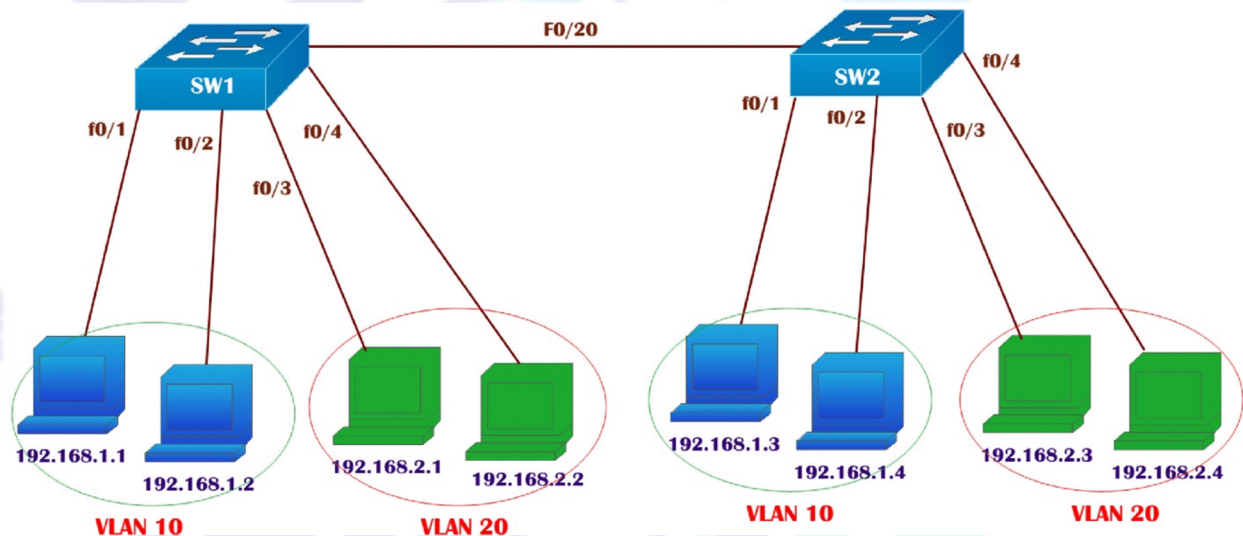
ISL (Inter-switch link)	IEEE 802.1Q
• It's a Cisco proprietary • It works with Ethernet, Token ring, FDDI • It adds 30 bytes of tag • No more supported on new cisco platforms	• IEEE Open standard • It works only on Ethernet • Only 4 Byte tag will be added to original frame.

Trunk Configuration

Switch(config)# **interface** <interface type> <interface no.>

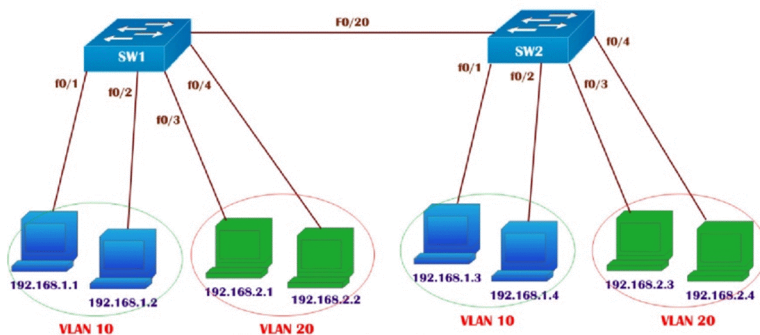
Switch(config-if)# **switchport mode trunk**

Switch(config-if)# **switchport trunk encapsulation dot1q**



LAB : Trunking

- ▶ Create Vlan 10 , Vlan 20 on both Switches
- ▶ Shift ports in to their respective VLAN as per the diagram.

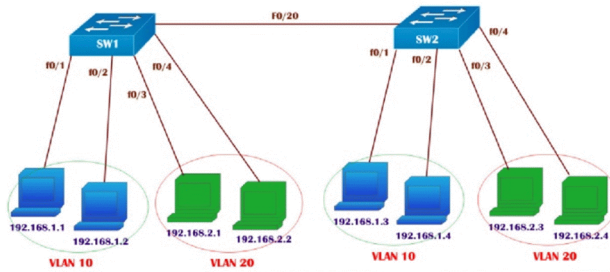


```
SW-2(config)#interface range f0/1 - 2
SW-2(config-if-range)#switchport mode access
SW-2(config-if-range)#switchport access vlan 10
SW-2(config-if-range)#exit
```

```
SW-2(config)#interface range f0/3 - 4
SW-2(config-if-range)#switchport mode access
SW-2(config-if-range)#switchport access vlan 20
SW-2(config-if-range)#end
```

```
SW-1(config)#interface range f0/1 - 2
SW-1(config-if-range)#switchport mode access
SW-1(config-if-range)#switchport access vlan 10
SW-1(config-if-range)#exit
```

```
SW-1(config)#interface range f0/3 - 4
SW-1(config-if-range)#switchport mode access
SW-1(config-if-range)#switchport access vlan 20
SW-1(config-if-range)#end
```

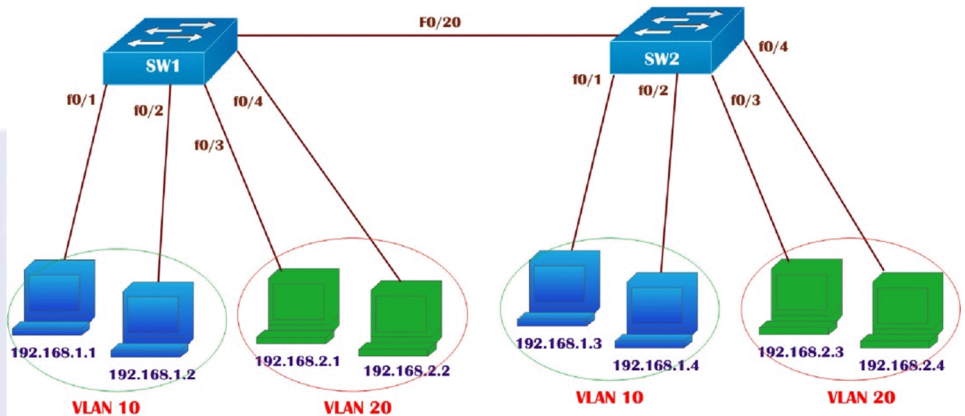
SW-2#show vlan

VLAN Name	Status	Ports
1 default	active	Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Fa0/11, Fa0/12 Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18, Fa0/19, Fa0/20 Fa0/21, Fa0/22, Fa0/23, Fa0/24 Gig1/1, Gig1/2
10 VLAN0010	active	Fa0/1, Fa0/2
20 VLAN0020	active	Fa0/3, Fa0/4

SW-1#show vlan

VLAN Name	Status	Ports
1 default	active	Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Fa0/11, Fa0/12 Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18, Fa0/19, Fa0/20 Fa0/21, Fa0/22, Fa0/23, Fa0/24 Gig1/1, Gig1/2
10 VLAN0010	active	Fa0/1, Fa0/2
20 VLAN0020	active	Fa0/3, Fa0/4

Configure F0/20 port between SW1 and SW2 as Trunk link



On both switches

SW-x(config)#interface fastEthernet 0/20

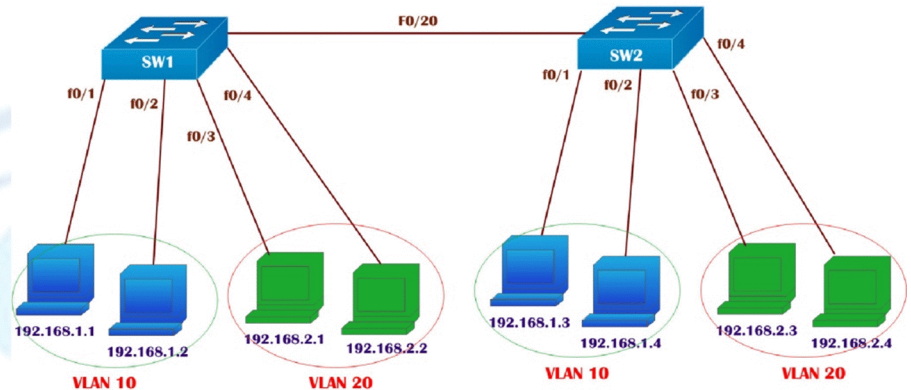
SW-x(config-if)#switchport mode trunk

SW-x(config-if)#switchport trunk encapsulation dot1q

SW-1#sh interfaces trunk

Port	Mode	Encapsulation	Status	Native vlan
Fa0/20	on	802.1q	trunking	1

Ensure That users of same VLAN on different Switches must communicate with each other



PC>ping 192.168.1.3

Pinging 192.168.1.3 with 32 bytes of data:

Reply from 192.168.1.3: bytes=32 time=17ms TTL=128

Reply from 192.168.1.3: bytes=32 time=13ms TTL=128

Reply from 192.168.1.3: bytes=32 time=12ms TTL=128

Reply from 192.168.1.3: bytes=32 time=10ms TTL=128

PC>ping 192.168.2.3

Pinging 192.168.2.3 with 32 bytes of data:

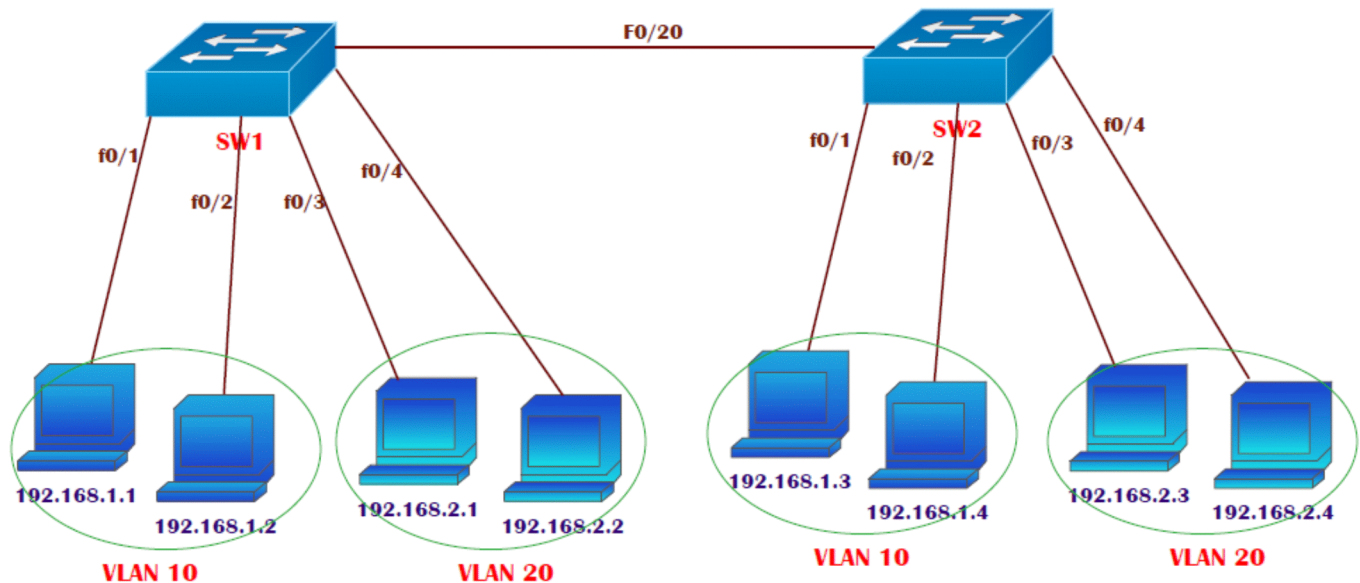
Reply from 192.168.2.3: bytes=32 time=13ms TTL=128

Reply from 192.168.2.3: bytes=32 time=12ms TTL=128

Reply from 192.168.2.3: bytes=32 time=13ms TTL=128

Reply from 192.168.2.3: bytes=32 time=13ms TTL=128

LAB: TRUNKING



TASK:

- Create Vlan 10 , Vlan 20 on both Switches
- Shift ports in to their respective VLAN as per the diagram.
- Configure F0/20 port between SW1 and SW2 as Trunk link
- Ensure That users of same VLAN on different Switches must communicate with each other

On SW-1

```
Switch(config)#hostname SW-1
SW-1(config)#interface range f0/1 - 2
SW-1(config-if-range)#switchport mode access
SW-1(config-if-range)#switchport access vlan 10
% Access VLAN does not exist. Creating vlan 10
SW-1(config-if-range)#exit
```

```
SW-1(config)#interface range f0/3 - 4
SW-1(config-if-range)#switchport mode access
SW-1(config-if-range)#switchport access vlan 20
SW-1(config-if-range)#end
```

SW-1#sh vlan

VLAN Name	Status	Ports
1 default	active	Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Fa0/11, Fa0/12 Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18, Fa0/19, Fa0/20 Fa0/21, Fa0/22, Fa0/23, Fa0/24 Gig1/1, Gig1/2
10 VLAN0010	active	Fa0/1, Fa0/2

20	VLAN0020	active	Fa0/3, Fa0/4
1002	fddi-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fddinet-default	act/unsup	
1005	trnet-default	act/unsup	

On SW-2

```
Switch(config)#hostname SW-2
SW-2(config)#interface range f0/1 - 2
SW-2(config-if-range)#switchport mode access
SW-2(config-if-range)#switchport access vlan 10
% Access VLAN does not exist. Creating vlan 10
SW-2(config-if-range)#exit
```

```
SW-2(config)#interface range f0/3 - 4
SW-2(config-if-range)#switchport mode access
SW-2(config-if-range)#switchport access vlan 20
% Access VLAN does not exist. Creating vlan 20
SW-2(config-if-range)#end
```

SW-2#sh vlan

VLAN Name	Status	Ports
1 default	active	Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Fa0/11, Fa0/12 Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18, Fa0/19, Fa0/20 Fa0/21, Fa0/22, Fa0/23, Fa0/24 Gig1/1, Gig1/2
10 VLAN0010	active	Fa0/1, Fa0/2
20 VLAN0020	active	Fa0/3, Fa0/4
1002 fddi-default	act/unsup	
1003 token-ring-default	act/unsup	
1004 fddinet-default	act/unsup	
1005 trnet-default	act/unsup	

From PC 192.168.1.1

```
PC>ipconfig
IP Address.....: 192.168.1.1
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 192.168.1.100
```

```
PC>ping 192.168.1.3
Pinging 192.168.1.3 with 32 bytes of data:
Request timed out.
Request timed out.
Request timed out.
Request timed out.
```

PC>ping 192.168.1.2

Pinging 192.168.1.2 with 32 bytes of data:

Reply from 192.168.1.2: bytes=32 time=13ms TTL=128

Reply from 192.168.1.2: bytes=32 time=9ms TTL=128

Reply from 192.168.1.2: bytes=32 time=8ms TTL=128

Reply from 192.168.1.2: bytes=32 time=8ms TTL=128

PC>ping 192.168.1.4

Pinging 192.168.1.4 with 32 bytes of data:

Request timed out.

Request timed out.

Request timed out.

Request timed out.

From PC 192.168.2.1

PC>ipconfig

IP Address.....: 192.168.2.1

Subnet Mask.....: 255.255.255.0

Default Gateway.....: 192.168.2.100

PC>ping 192.168.2.2

Pinging 192.168.2.2 with 32 bytes of data:

Reply from 192.168.2.2: bytes=32 time=17ms TTL=128

Reply from 192.168.2.2: bytes=32 time=7ms TTL=128

Reply from 192.168.2.2: bytes=32 time=9ms TTL=128

Reply from 192.168.2.2: bytes=32 time=8ms TTL=128

SERVER>ping 192.168.2.3

Pinging 192.168.2.3 with 32 bytes of data:

Request timed out.

Request timed out.

Request timed out.

Request timed out.

SERVER>ping 192.168.2.4

Pinging 192.168.2.4 with 32 bytes of data:

Request timed out.

Request timed out.

Request timed out.

Request timed out.

NOTE:

- From the above verification
- Users of the same VLAN connected on the same switch can ping each other
- Same vlan users on different switches are not able to ping each other
- In order to communicate between same vlan on different switches, there should be trunking configured on link (f0/20) between the switches

To configure trunking

```
SW-1(config)#interface fastEthernet 0/20
SW-1(config-if)#switchport mode trunk
SW-1(config-if)#switchport trunk encapsulation dot1q
```

```
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/20, changed state to down
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/20, changed state to up
```

```
SW-2(config)#int f0/20
SW-2(config-if)#switchport mode trunk
SW-2(config-if)#switchport trunk encapsulation dot1q
```

SW-1#sh interfaces trunk

Port	Mode	Encapsulation	Status	Native vlan
Fa0/20	on	802.1q	trunking	1
Port	Vlans allowed on trunk			
Fa0/20	1-1005			
Port	Vlans allowed and active in management domain			
Fa0/20	1,10,20			
Port	Vlans in spanning tree forwarding state and not pruned			
Fa0/20	1,10,20			

SW-2#sh interfaces trunk

Port	Mode	Encapsulation	Status	Native vlan
Fa0/20	on	802.1q	trunking	1
Port	Vlans allowed on trunk			
Fa0/20	1-1005			
Port	Vlans allowed and active in management domain			
Fa0/20	1,10,20			
Port	Vlans in spanning tree forwarding state and not pruned			
Fa0/20	1,10,20			

From PC 192.168.1.1

```
PC>ipconfig
IP Address.....: 192.168.1.1
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 192.168.1.100
```

```
PC>ping 192.168.1.3
Pinging 192.168.1.3 with 32 bytes of data:
```

```
Reply from 192.168.1.3: bytes=32 time=17ms TTL=128
Reply from 192.168.1.3: bytes=32 time=13ms TTL=128
Reply from 192.168.1.3: bytes=32 time=12ms TTL=128
Reply from 192.168.1.3: bytes=32 time=10ms TTL=128
```


PC>ping 192.168.1.4

Pinging 192.168.1.4 with 32 bytes of data:

Reply from 192.168.1.4: bytes=32 time=25ms TTL=128

Reply from 192.168.1.4: bytes=32 time=14ms TTL=128

Reply from 192.168.1.4: bytes=32 time=12ms TTL=128

Reply from 192.168.1.4: bytes=32 time=13ms TTL=128

From PC 192.168.2.1

PC>ipconfig

IP Address.....: 192.168.2.1

Subnet Mask.....: 255.255.255.0

Default Gateway.....: 192.168.2.100

PC>ping 192.168.2.3

Pinging 192.168.2.3 with 32 bytes of data:

Reply from 192.168.2.3: bytes=32 time=13ms TTL=128

Reply from 192.168.2.3: bytes=32 time=12ms TTL=128

Reply from 192.168.2.3: bytes=32 time=13ms TTL=128

Reply from 192.168.2.3: bytes=32 time=13ms TTL=128

PC>ping 192.168.2.4

Pinging 192.168.2.4 with 32 bytes of data:

Reply from 192.168.2.4: bytes=32 time=26ms TTL=128

Reply from 192.168.2.4: bytes=32 time=12ms TTL=128

Reply from 192.168.2.4: bytes=32 time=12ms TTL=128

Reply from 192.168.2.4: bytes=32 time=13ms TTL=128

TASK:

- Configure The Trunk Link Such That It Only Allow The Vlan 10 , 20, 30 , 40 Traffic Should Only Be Allowed (No Other Vlan Traffic Should Be Send)

On both switches (SW1/SW2)

SW-x(config)#int f0/20

SW-x(config-if)#switchport trunk allowed vlan ?

WORD VLAN IDs of the allowed VLANs when this port is in trunking mode

add add VLANs to the current list

all all VLANs

except all VLANs except the following

none no VLANs

remove remove VLANs from the current list

SW-x(config-if)#switchport trunk allowed vlan 10,20,30,40

SW-1#sh interfaces trunk

Port	Mode	Encapsulation	Status	Native vlan
------	------	---------------	--------	-------------

```

Fa0/20    on      802.1q    trunking    1
Port      Vlans allowed on trunk
Fa0/20    10,20,30,40
Port      Vlans allowed and active in management domain
Fa0/20    10,20
Port      Vlans in spanning tree forwarding state and not pruned
Fa0/20    10,20

```

SW-2#sh interfaces trunk

```

Port      Mode      Encapsulation  Status      Native vlan
Fa0/20    on      802.1q        trunking    1
Port      Vlans allowed on trunk
Fa0/20    10,20,30,40
Port      Vlans allowed and active in management domain
Fa0/20    10,20

Port      Vlans in spanning tree forwarding state and not pruned
Fa0/20    10,20

```

TASK:

- Create vlan 50, 60,70,80 on both switches
- Configure the trunk link f0/20 to add vlan 50 ,60,70,80 to the existing trunk allowed list

On both switches (SW1/SW2)

```

SW-x(config)#vlan 50
SW-x(config-vlan)#vlan 60
SW-x(config-vlan)#vlan 70
SW-x(config-vlan)#vlan 80
SW-x(config-vlan)#end

```

```

SW-x(config-if)#switchport trunk allowed vlan add 50,60,70,80

```

SW-1#sh interfaces trunk

```

Port      Mode      Encapsulation  Status      Native vlan
Fa0/20    on      802.1q        trunking    1
Port      Vlans allowed on trunk
Fa0/20    10,20,30,40,50,60,70,80
Port      Vlans allowed and active in management domain
Fa0/20    10,20,50,60
Port      Vlans in spanning tree forwarding state and not pruned
Fa0/20    10,20,50,60

```

SW-2#sh interfaces trunk

```

Port      Mode      Encapsulation  Status      Native vlan
Fa0/20    on      802.1q        trunking    1
Port      Vlans allowed on trunk
Fa0/20    10,20,30,40,50,60,70,80
Port      Vlans allowed and active in management domain
Fa0/20    10,20,50,60

```

Port	Vlans in spanning tree forwarding state and not pruned
Fa0/20	10,20,50,60

TASK

- Configure the trunk link f0/20 to remove vlan 70,80 to the existing trunk allowed list

```
SW-1(config)#int f0/20
```

```
SW-1(config-if)#switchport trunk allowed vlan remove 70,80
```

```
SW-1#sh interfaces trunk
```

Port	Mode	Encapsulation	Status	Native vlan
Fa0/20	on	802.1q	trunking	1

Port	Vlans allowed on trunk
Fa0/20	10,20,30,40,50,60

Port	Vlans allowed and active in management domain
Fa0/20	10,20,50,60

Port	Vlans in spanning tree forwarding state and not pruned
Fa0/20	10,20,50,60

```
SW-2#sh interfaces trunk
```

Port	Mode	Encapsulation	Status	Native vlan
Fa0/20	on	802.1q	trunking	1

Port	Vlans allowed on trunk
Fa0/20	10,20,30,40,50,60

Port	Vlans allowed and active in management domain
Fa0/20	10,20,50,60

Port	Vlans in spanning tree forwarding state and not pruned
Fa0/20	10,20,50,60

DTP (DYNAMIC TRUNKING PROTOCOL)

Trunking can be done dynamically through negotiation process

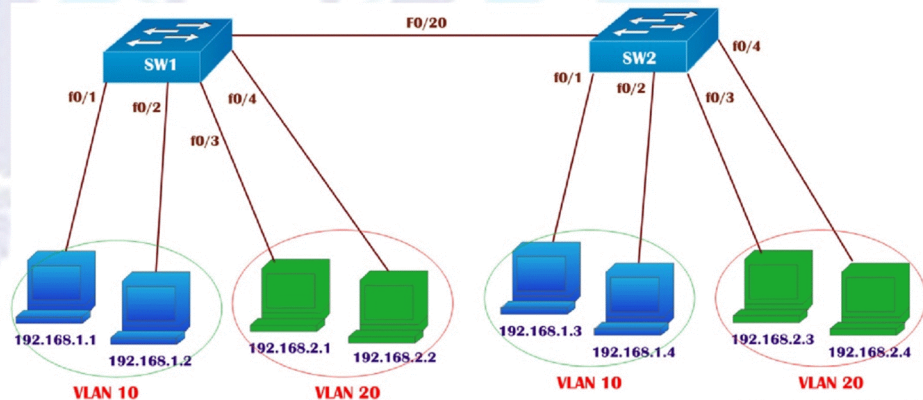
Switch# sh dtp

Global DTP information

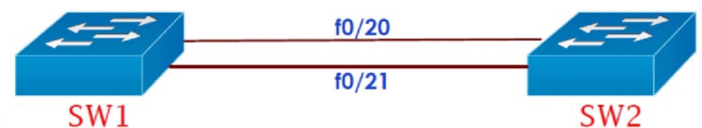
Sending DTP Hello packets every 30 seconds

Dynamic Trunk timeout is 300 seconds

0 interfaces using DTP



DTP MODES

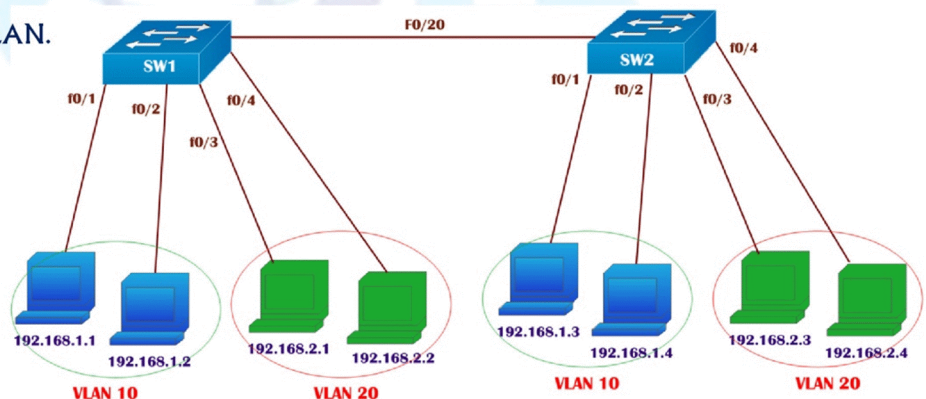


TRUNK

- Configuring trunk manually
- The port still negotiates trunking with the port on the other end of the link.

ACCESS

- Configuring access manually
- The port is a user port in a single VLAN.



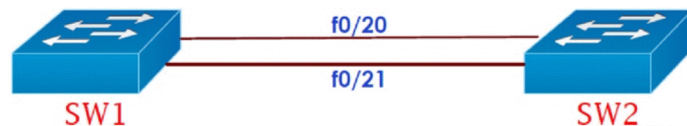
DTP MODES

DESIRABLE:

- desires to become trunk (always want to become trunk)
- Sends and reply to DTP messages
- It becomes a trunk if the port on the other switch is set to **trunk**, **dynamic desirable** or **dynamic auto** mode.

AUTO:

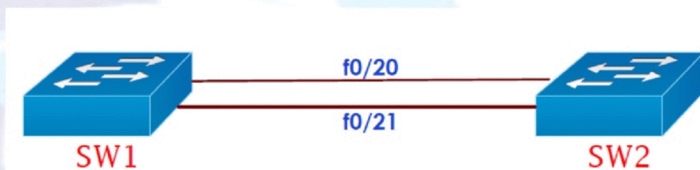
- Only reply to DTP messages (not send)
- Default mode on most of the modern switches
- It becomes a trunk if the other end is set to **trunk** or **dynamic desirable** mode.



DTP MODES

NO-NEGOTIATE

- Turn off DTP messages (disable DTP).
- The port is a trunk and does not do DTP negotiation with the other side of the link.



DTP can be disabled either by

- ▶ configuring as access port using **switchport mode access**
- ▶ or using **switchport nonegotiate** commands

Switchport Mode Interactions

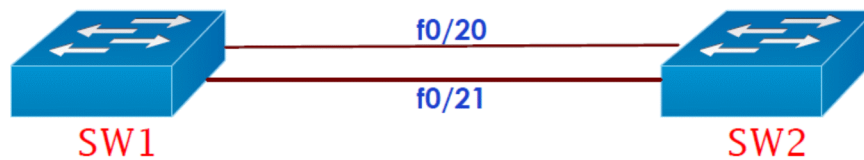
	Dynamic Auto	Dynamic Desirable	Trunk	Access
Dynamic Auto	Access	Trunk	Trunk	Access
Dynamic Desirable	Trunk	Trunk	Trunk	Access
Trunk	Trunk	Trunk	Trunk	Not recommended
Access	Access	Access	Not recommended	Access

Note: Table assumes DTP is enabled at both ends.

- show dtp interface – to determine current setting



LAB: VERIFYING DTP



TASK:

- Configure f0/20 of SW1 to actively negotiate the DTP messages and SW2 f0/20 port should only reply to the DTP messages
- Configure f0/21 of SW1 and SW2 should not negotiate any DTP messages

Sw-1# sh interfaces fa0/20 switchport

Name: Fa0/20

Switchport: Enabled

Administrative Mode: dynamic auto

Operational Mode: static access

Administrative Trunking Encapsulation: dot1q

Operational Trunking Encapsulation: native

On SW-1

Sw-1(config)#int f0/20

Sw-1(config-if)#switchport mode ?

access Set trunking mode to ACCESS unconditionally

dynamic Set trunking mode to dynamically negotiate access or trunk mode

trunk Set trunking mode to TRUNK unconditionally

Sw-1(config-if)#switchport mode dynamic desirable

SW-1#sh interfaces fa0/20 switchport

Name: Fa0/20

Switchport: Enabled

Administrative Mode: dynamic desirable

Operational Mode: trunk

Administrative Trunking Encapsulation: dot1q

SW-1# sh interfaces trunk

Port	Mode	Encapsulation	Status	Native vlan
Fa0/20	auto	n-802.1q	trunking	1
Port	Vlans allowed on trunk			
Fa0/20	1-1005			

Switch#sh interfaces trunk

Port	Mode	Encapsulation	Status	Native vlan
Fa0/20	auto	n-802.1q	trunking	1

Port	Vlans allowed on trunk
Fa0/20	1-1005
Port	Vlans allowed and active in management domain
Fa0/20	1
Port	Vlans in spanning tree forwarding state and not pruned
Fa0/20	1

TASK: Configure SW1 and SW2 to Configure Manual Trunk and Disable the DTP negotiation Process.

On SW1/SW2

```
Sw-x(config)#int f0/21
Sw-x(config-if)#switchport mode trunk
Sw-x(config-if)#switchport trunk encapsulation dot1q
Sw-x(config-if)#switchport nonegotiate
```

Sw-1#sh interfaces trunk

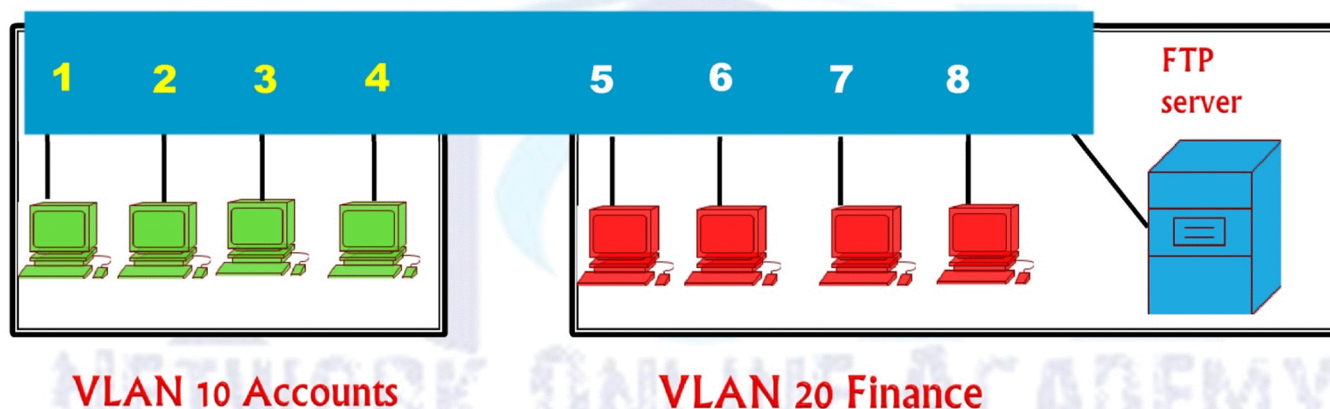
Port	Mode	Encapsulation	Status	Native vlan
Fa0/20	auto	n-802.1q	trunking	1
Fa0/21	on	802.1q	trunking	1
Port	Vlans allowed on trunk			
Fa0/20	1-1005			
Fa0/21	1-1005			
Port	Vlans allowed and active in management domain			
Fa0/20	1			
Fa0/21	1			
Port	Vlans in spanning tree forwarding state and not pruned			
Fa0/20	1			
Fa0/21	1			

Sw-2#sh interfaces trunk

Port	Mode	Encapsulation	Status	Native vlan
Fa0/20	auto	n-802.1q	trunking	1
Fa0/21	on	802.1q	trunking	1
Port	Vlans allowed on trunk			
Fa0/20	1-1005			
Fa0/21	1-1005			
Port	Vlans allowed and active in management domain			
Fa0/20	1			
Fa0/21	1			
Port	Vlans in spanning tree forwarding state and not pruned			
Fa0/20	1			
Fa0/21	none			

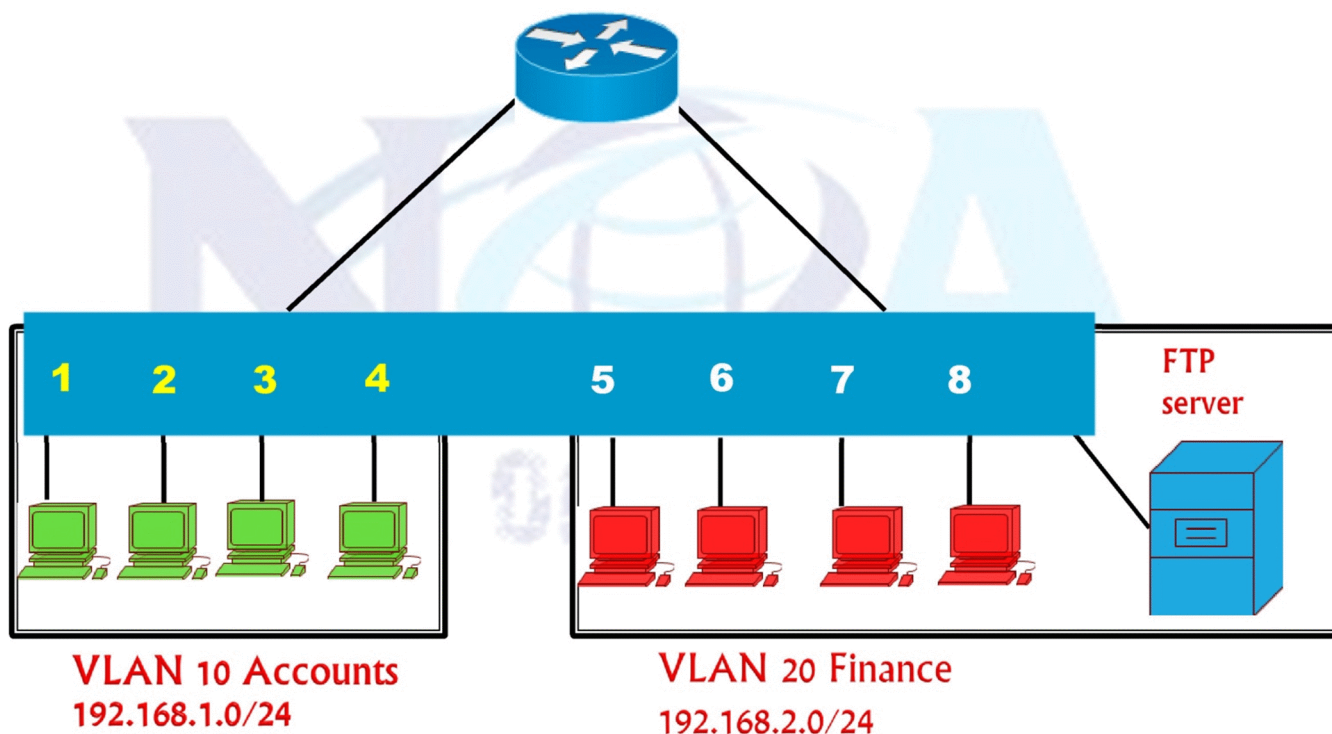
Inter -VLAN Routing

allowing the users of one VLAN to access resources of other VLAN



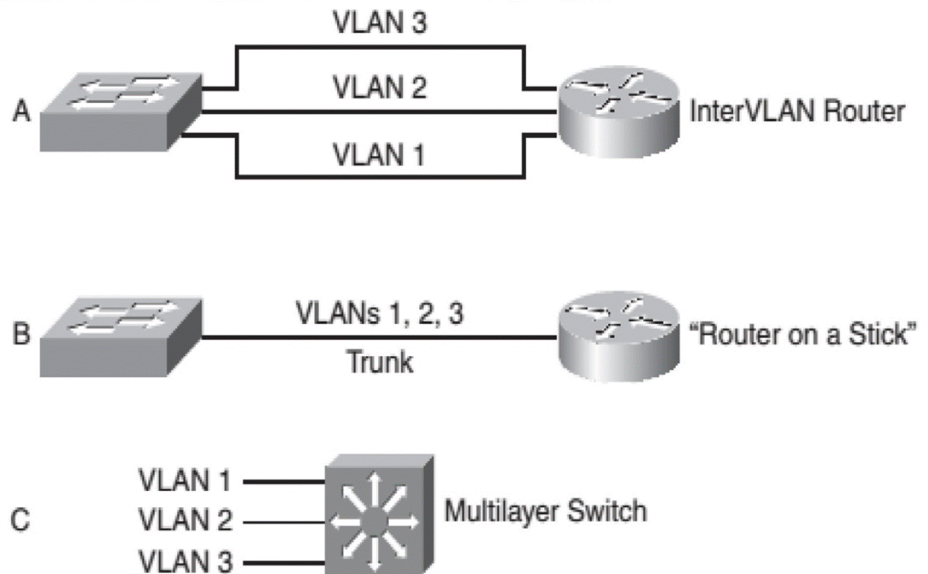
Inter -VLAN Routing

- Need a at-least one router
- Every VLAN must have a default gateway

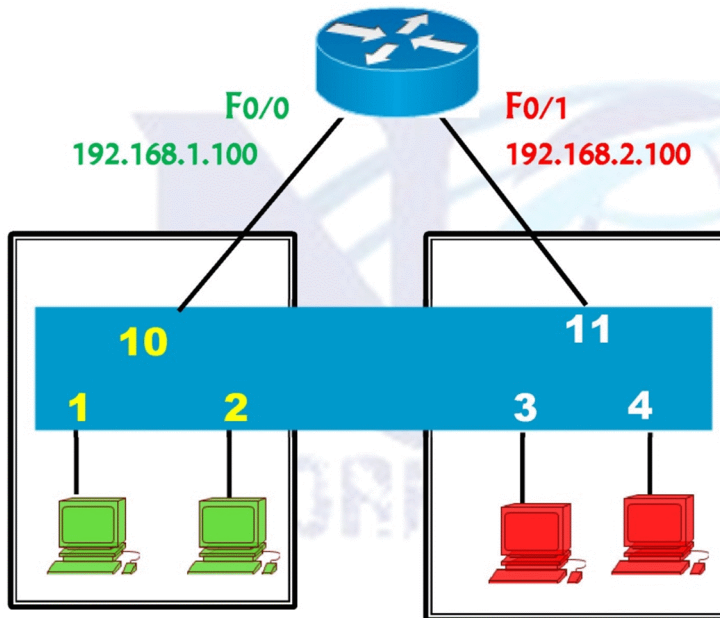


Inter-Vlan Routing Methods

- Separate Physical Gateway on Router
- Using Sub-interfaces
- Using Layer 3 Switch



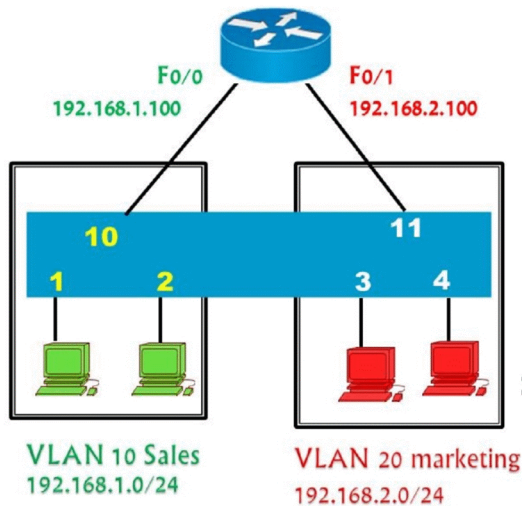
Inter- VLAN routing using separate interfaces



- Need a at-least one router
- Every VLAN must have a default gateway

1, 2, 10 - vlan 10
3, 4, 11 - vlan 20

Inter-Vlan Routing using Separate Physical Gateway on Router



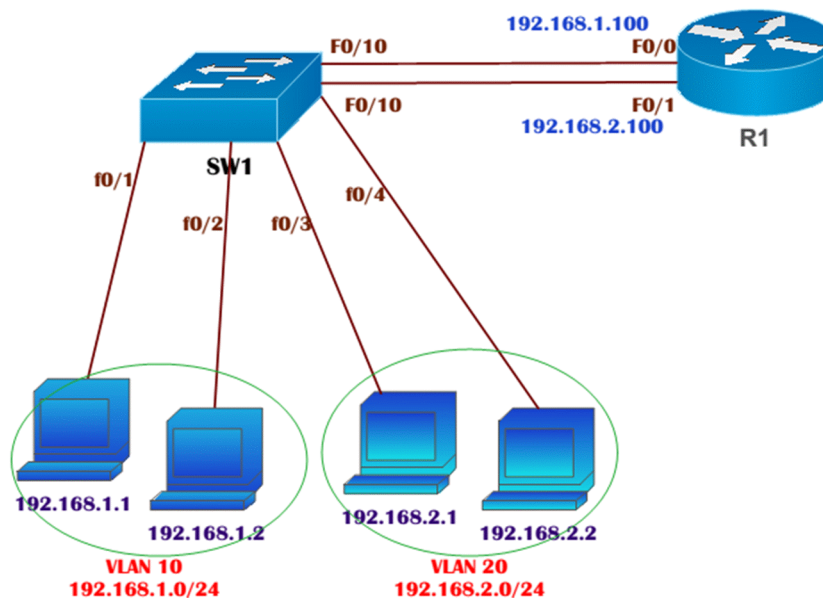
```
Router(config)#interface FastEthernet0/0
Router(config-if)# ip address 192.168.1.100 255.255.255.0
Router(config-if)#no shutdown
Router(config-if)#exit
```

```
Router(config)#interface FastEthernet0/1
Router(config-if)# ip address 192.168.2.100 255.255.255.0
Router(config-if)#no shutdown
Router(config-if)#exit
```

Switch#sh vlan

VLAN Name	Status	Ports
1 default	active	Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/12, Fa0/13, Fa0/14 Fa0/15, Fa0/16, Fa0/17, Fa0/18 Fa0/19, Fa0/20, Fa0/21, Fa0/22 Fa0/23, Fa0/24, Gig1/1, Gig1/2
10 sales	active	Fa0/1, Fa0/2, Fa0/10
20 marketing	active	Fa0/3, Fa0/4, Fa0/11

LAB: Inter-Vlan Routing Using Legacy Method:



TASK

- Create Vlan 10, Vlan 20 on SW1 and assign ports in to their respective VLAN as per the diagram.
- Ensure That users of VLAN 10 and 20 communicate with each other

```
Switch(config)#vlan 10
Switch(config-vlan)#name sales
```

```
Switch(config-vlan)#exit
```

```
Switch(config)#vlan 20
```

```
Switch(config-vlan)#name marketing
```

```
Switch(config-vlan)#exit
```

```
Switch(config)#interface FastEthernet0/1
```

```
Switch(config-if)# switchport access vlan 10
```

```
Switch(config-if)# switchport mode access
```

```
Switch(config-if)#interface FastEthernet0/2
```

```
Switch(config-if)# switchport access vlan 10
```

```
Switch(config-if)# switchport mode access
```

```
Switch(config-if)#interface FastEthernet0/3
```

```
Switch(config-if)# switchport access vlan 20
```

```
Switch(config-if)# switchport mode access
```

```
Switch(config-if)#interface FastEthernet0/4
```

```
Switch(config-if)# switchport access vlan 20
```

```
Switch(config-if)# switchport mode access
```

```
Switch(config-if)#exit
```



```
Switch(config)#interface FastEthernet0/10
Switch(config-if)# switchport access vlan 10
Switch(config-if)# switchport mode access
```

```
Switch(config-if)#interface FastEthernet0/11
Switch(config-if)# switchport access vlan 20
Switch(config-if)# switchport mode access
Switch(config-if)#end
```

```
Switch#sh vlan
```

VLAN Name	Status	Ports
1 default	active	Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/12, Fa0/13, Fa0/14 Fa0/15, Fa0/16, Fa0/17, Fa0/18 Fa0/19, Fa0/20, Fa0/21, Fa0/22 Fa0/23, Fa0/24, Gig1/1, Gig1/2
10 sales	active	Fa0/1, Fa0/2, Fa0/10
20 marketing	active	Fa0/3, Fa0/4, Fa0/11
1002 fddi-default	act/unsup	

```
Router(config)#interface FastEthernet0/0
Router(config-if)# ip address 192.168.1.100 255.255.255.0
Router(config-if)#no shutdown
Router(config-if)#exit
```

```
Router(config)#interface FastEthernet0/1
Router(config-if)# ip address 192.168.2.100 255.255.255.0
Router(config-if)#no shutdown
Router(config-if)#exit
Router(config)#end
```

```
Router#sh ip int brief
```

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.1.100	YES	manual	up	up
FastEthernet0/1	192.168.2.100	YES	manual	up	up

```
Router#sh ip route
```

```
P - periodic downloaded static route
Gateway of last resort is not set
C 192.168.1.0/24 is directly connected, FastEthernet0/0
C 192.168.2.0/24 is directly connected, FastEthernet0/1
```

```
PC>ipconfig
```

FastEthernet0 Connection:(default port)
Link-local IPv6 Address.....: ::
IP Address.....: 192.168.1.1
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 192.168.1.100

PC>ping 192.168.2.1

Pinging 192.168.2.1 with 32 bytes of data:

Request timed out.

Reply from 192.168.2.1: bytes=32 time=0ms TTL=127

Reply from 192.168.2.1: bytes=32 time=0ms TTL=127

Reply from 192.168.2.1: bytes=32 time=0ms TTL=127

PC>tracert 192.168.2.1

Tracing route to 192.168.2.1 over a maximum of 30 hops:

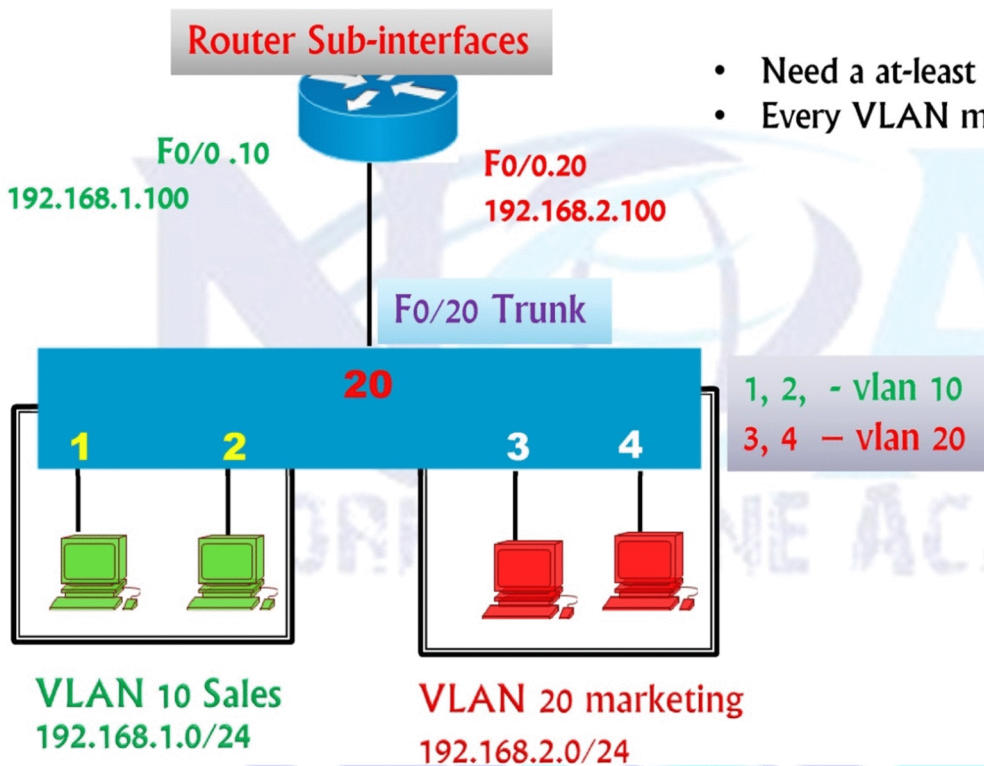
1	13 ms	0 ms	0 ms	192.168.1.100
---	-------	------	------	---------------

2	0 ms	0 ms	0 ms	192.168.2.1
---	------	------	------	-------------

Trace complete.

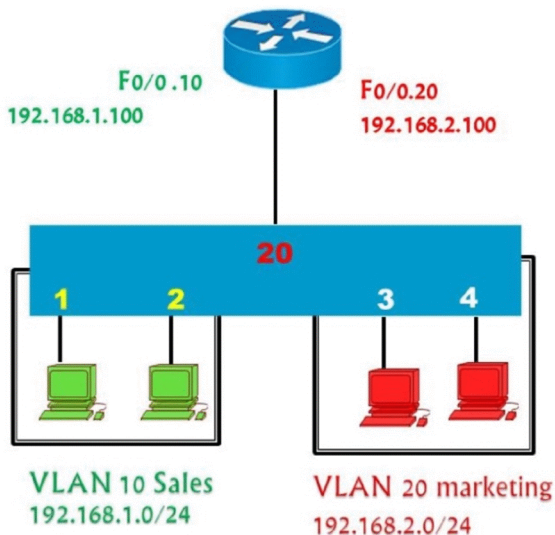


Inter- VLAN routing using sub-interfaces



- Need a at-least one router
- Every VLAN must have a default gateway

Inter VLAN-routing using Router (Router On Stick)



SW-1#sh vlan

VLAN Name	Status	Ports
1 default	active	Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Fa0/11, Fa0/12 Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18, Fa0/19, Fa0/20 Fa0/21, Fa0/22, Fa0/23, Fa0/24 Gig1/1, Gig1/2
10 VLAN0010	active	Fa0/1, Fa0/2
20 VLAN0020	active	Fa0/3, Fa0/4

SW-1(config)#interface fastEthernet 0/20

(Interface facing Router)

SW-1(config-if)#switchport mode trunk

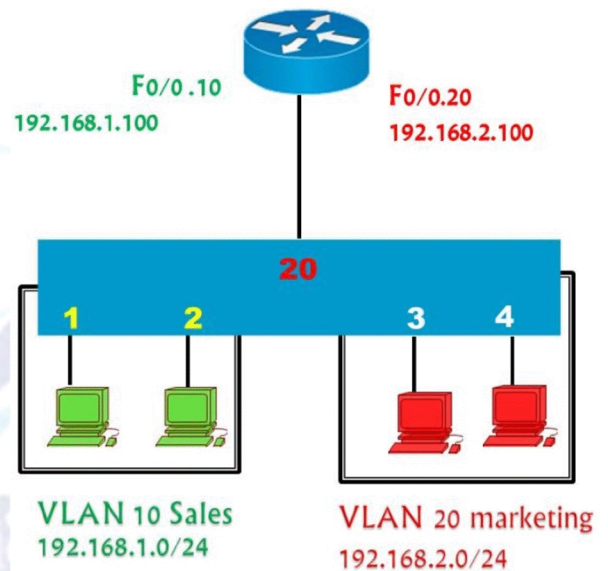
SW-1(config-if)#switchport trunk encapsulation dot1q

INTER VLAN-ROUTING USING ROUTER (Router On Stick)

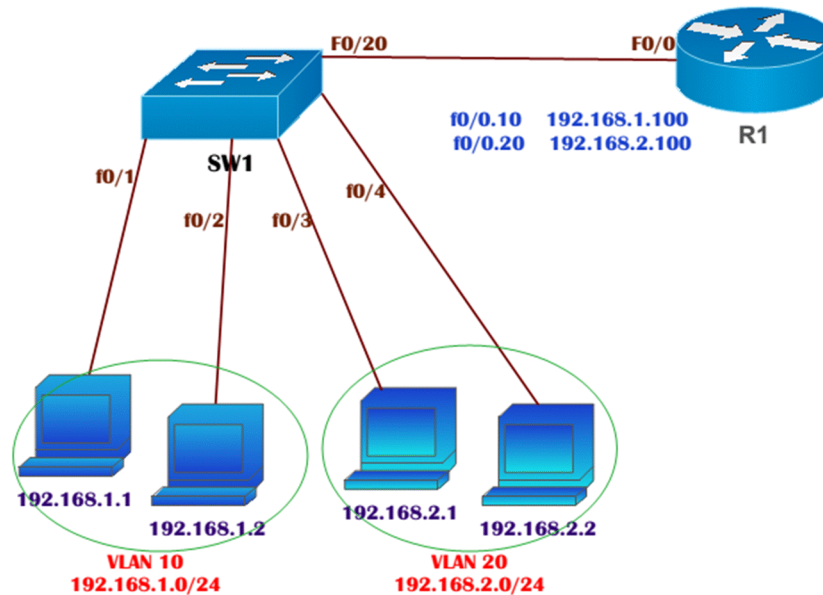
```
R-1(config)#int fa0/0
R-1(config-if)# no shutdown
R-1(config-if)# no ip address
R-1(config-if)# exit
```

```
R-1(config)#int fa0/0.10
R-1(config-sub-if)# encapsulation dot1Q 10
    It should be the exact vlan no ( vlan 10)
R-1(config-sub-if)# ip add 192.168.1.100 255.255.255.0
R-1(config-sub-if)# exit
```

```
R-1(config)#int fa0/0.20
R-1(config-sub-if)# encapsulation dot1Q 20
    It should be the exact vlan no ( vlan 20)
R-1(config-sub-if)# ip add 192.168.2.100 255.255.255.0
```



LAB: INTER VLAN-ROUTING USING ROUTER (Router On Stick)



TASK:

- Create Vlan 10 , Vlan 20 on SW1
- Shift ports in to their respective VLAN as per the diagram.
- Configure F0/20 port as Trunk link.
- Create sub interfaces on router port f0/0
- Ensure That users of VLAN 10 and 20 communicate with each other

On SW-1

```
Switch (config)#hostname SW-1
SW-1(config)#interface range f0/1 - 2
SW-1(config-if-range)#switchport mode access
SW-1(config-if-range)#switchport access vlan 10
% Access VLAN does not exist. Creating vlan 10
SW-1(config-if-range)#exit
```

```
SW-1(config)#interface range f0/3 - 4
SW-1(config-if-range)#switchport mode access
SW-1(config-if-range)#switchport access vlan 20
SW-1(config-if-range)#end
```

SW-1#sh vlan

VLAN Name	Status	Ports
1 default	active	Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Fa0/11, Fa0/12 Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18, Fa0/19, Fa0/20

Fa0/21, Fa0/22, Fa0/23, Fa0/24
Gig1/1, Gig1/2

10	VLAN0010	active	Fa0/1, Fa0/2
20	VLAN0020	active	Fa0/3, Fa0/4
1002	fddi-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fddinet-default	act/unsup	
1005	trnet-default	act/unsup	

Trunk link configuration

```
SW-1(config)#interface fastEthernet 0/20
```

(Interface facing Router)

```
SW-1(config-if)#switchport mode trunk
```

```
SW-1(config-if)#switchport trunk encapsulation dot1q
```

- A router on a stick can be used to route between VLANs using either ISL or 802.1Q as the trunking protocol.
- A router on a stick requires subinterfaces, one for each VLAN.

Creating sub interfaces on router interface f0/0

```
R-1(config)#int fa0/0
```

```
R-1(config-if)# no shutdown
```

```
R-1(config-if)# exit
```

```
R-1(config)#int fa0/0.10
```

```
R-1(config-sub-if)# encapsulation dot1Q 10
```

It should be the exact vlan no (vlan 10)

```
R-1(config-sub-if)# ip add 192.168.1.100 255.255.255.0
```

```
R-1(config-sub-if)# exit
```

```
R-1(config)#int fa0/0.20
```

```
R-1(config-sub-if)# encapsulation dot1Q 20
```

It should be the exact vlan no (vlan 20)

```
R-1(config-sub-if)# ip add 192.168.2.100 255.255.255.0
```

```
Router#sh ip int brief
```

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	unassigned	YES	unset	up	up
FastEthernet0/0.10	192.168.1.100	YES	manual	up	up
FastEthernet0/0.20	192.168.2.100	YES	manual	up	up

Verify connectivity

PC>ipconfig

IP Address.....: 192.168.1.1
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 192.168.1.100

PC>ping 192.168.2.1

Pinging 192.168.2.1 with 32 bytes of data:

Request timed out.

Reply from 192.168.2.1: bytes=32 time=62ms TTL=127

Reply from 192.168.2.1: bytes=32 time=125ms TTL=127

Reply from 192.168.2.1: bytes=32 time=109ms TTL=127

PC>tracert 192.168.2.1

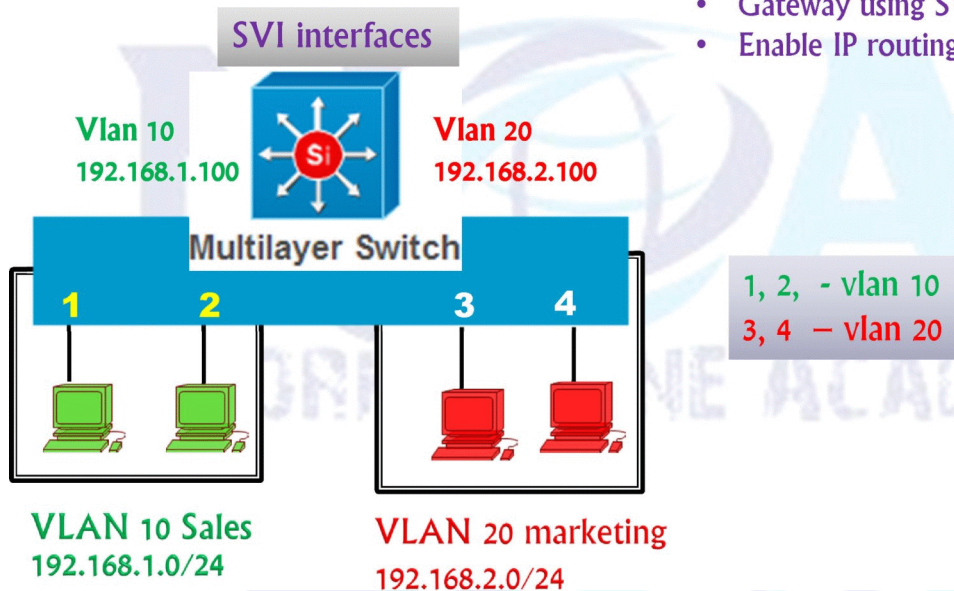
Tracing route to 192.168.2.1 over a maximum of 30 hops:

1	47 ms	63 ms	62 ms	192.168.1.100
2	109 ms	125 ms	78 ms	192.168.2.1



Inter Vlan-Routing Using MLS

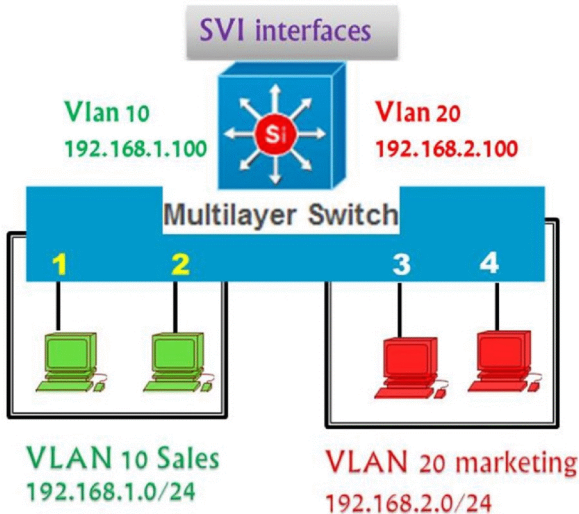
- Need at-least one Multi-layer Switch
- Gateway using SVI interfaces.
- Enable IP routing on Switch.



Inter VLAN-Routing Using MLS – Lab

SW-1#sh vlan

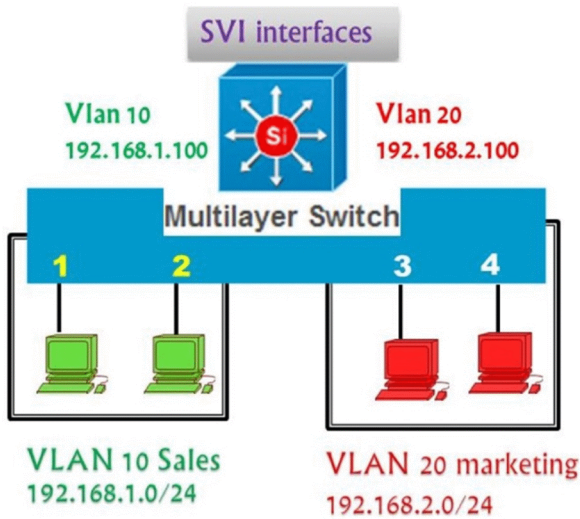
VLAN Name	Status	Ports
1 default	active	Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Fa0/11, Fa0/12 Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18, Fa0/19, Fa0/20 Fa0/21, Fa0/22, Fa0/23, Fa0/24 Gig1/1, Gig1/2
10 VLAN0010	active	Fa0/1, Fa0/2
20 VLAN0020	active	Fa0/3, Fa0/4



```
Switch (config)#int vlan 10
Switch(config-if)#ip address 192.168.1.100 255.255.255.0
Switch(config-if)#no shutdown
Switch(config-if)#exit
```

```
Switch(config)#int vlan 20
Switch(config-if)#ip address 192.168.2.100 255.255.255.0
Switch(config-if)#no shutdown
Switch(config-if)#exit
```

Switch(config)#ip routing



PC>ping 192.168.2.1

Pinging 192.168.2.1 with 32 bytes of data:

Request timed out.

Reply from 192.168.2.1: bytes=32 time=62ms TTL=127

Reply from 192.168.2.1: bytes=32 time=125ms TTL=127

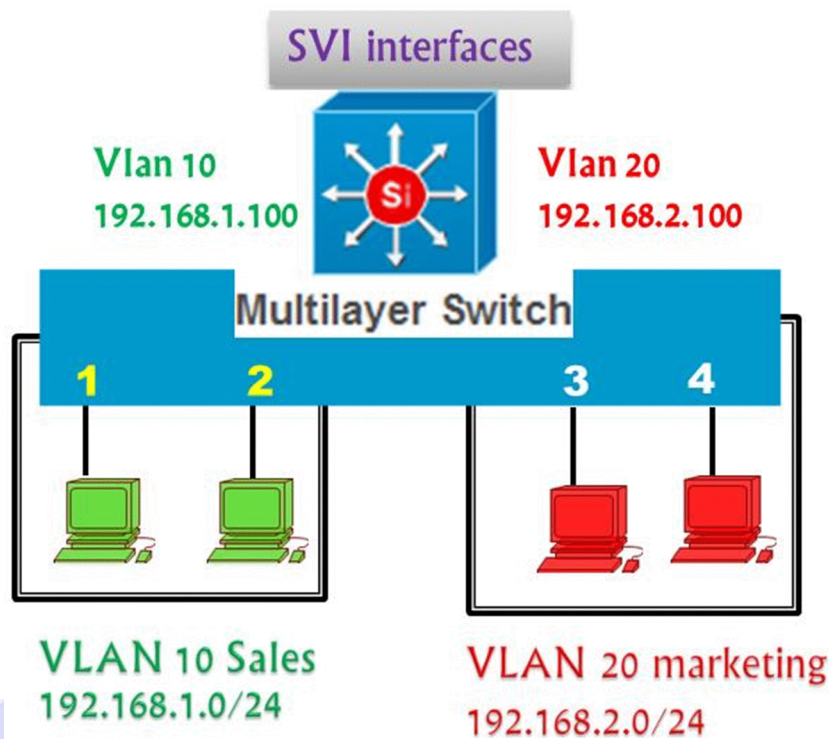
Reply from 192.168.2.1: bytes=32 time=109ms TTL=127

PC>tracert 192.168.2.1

Tracing route to 192.168.2.1 over a maximum of 30 hops:

1	47 ms	63 ms	62 ms	192.168.1.100
2	109 ms	125 ms	78 ms	192.168.2.1

LAB: Inter Vlan-Routing Using MLS



TASK:

- Create vlan and shift the ports as per the diagram
- create SVI (switch virtual interface) for each vlan and assign IP as per vlan addressing as per the diagram given
- Ensure that IP routing is enabled on Multilayer Switch
- verify connectivity between vlans (ping 192.168.1.1 ---192.168.2.1)

TASK: Create Vlan and Shift the Ports According To the Diagram

```
Switch(config)#vlan 10
Switch(config-vlan)#vlan 20
Switch(config-vlan)#exit
```

```
Switch(config)#int range f0/1 - 2
Switch(config-if-range)#switchport mode access
Switch(config-if-range)#switchport access vlan 10
Switch(config-if-range)#exit
```

```
Switch(config)#int range f0/3 - 4
Switch(config-if-range)#switchport mode access
Switch(config-if-range)#switchport access vlan 20
Switch(config-if-range)#exit
```

```
SW-1#sh vlan
```

VLAN Name	Status	Ports
1 default	active	Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Fa0/11, Fa0/12 Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18, Fa0/19, Fa0/20 Fa0/21, Fa0/22, Fa0/23, Fa0/24 Gig1/1, Gig1/2
10 VLAN0010	active	Fa0/1, Fa0/2
20 VLAN0020	active	Fa0/3, Fa0/4
1002 fddi-default	act/unsup	
1003 token-ring-default	act/unsup	
1004 fddinet-default	act/unsup	
1005 trnet-default	act/unsup	

TASK: Create SVI (Switch Virtual Interface) For Each Vlan

```
Switch (config)#int vlan 10
Switch(config-if)#ip address 192.168.1.100 255.255.255.0
Switch(config-if)#no shutdown
Switch(config-if)#exit
```

```
Switch(config)#int vlan 20
Switch(config-if)#ip address 192.168.2.100 255.255.255.0
Switch(config-if)#no shutdown
Switch(config-if)#exit
```

Switch # sh ip int brief

Vlan10	192.168.1.100	YES	manual up	up
Vlan20	192.168.2.100	YES	manual up	up

- The VLAN must be defined and active on the switch before the SVI can be used.
- The VLAN and the SVI are configured separately, even though they interoperate. Creating or configuring the SVI doesn't create or configure the VLAN; you still must define each one independently

Switch(config)#ip routing

- Enable routing on the switch by using the [ip routing](#) command. Even if IP routing was previously enabled, this step ensures that it is activated.

Task : Verify Connectivity between VLANs (Ping 192.168.1.1 ---192.168.2.1)

PC>ipconfig

IP Address.....: 192.168.1.1
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 192.168.1.100

PC>ping 192.168.2.1

Pinging 192.168.2.1 with 32 bytes of data:

Request timed out.

Reply from 192.168.2.1: bytes=32 time=62ms TTL=127

Reply from 192.168.2.1: bytes=32 time=125ms TTL=127

Reply from 192.168.2.1: bytes=32 time=109ms TTL=127

PC>tracert 192.168.2.1

Tracing route to 192.168.2.1 over a maximum of 30 hops:

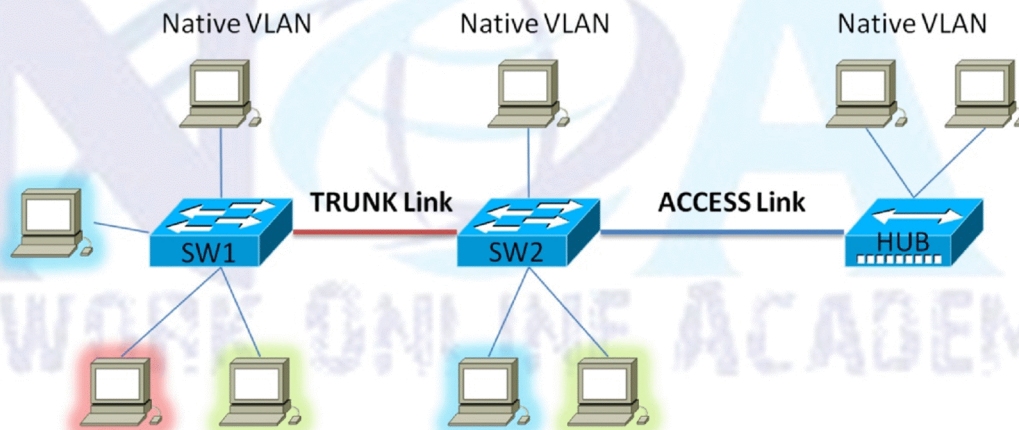
1 47 ms 63 ms 62 ms 192.168.1.100

2 109 ms 125 ms 78 ms 192.168.2.1



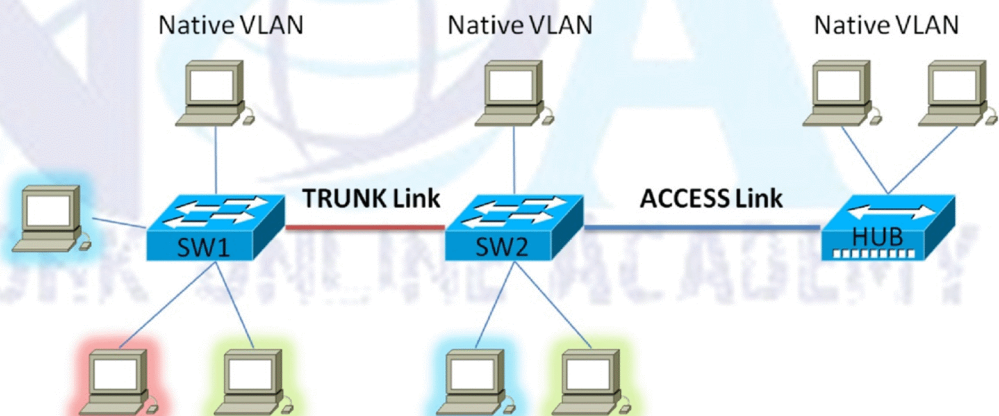
Native VLAN

- ❖ If a packet is received on a dot1q link, that does not have VLAN tagged, it is assumed that it belongs to native VLAN.
- ❖ Default native vlan is VLAN 1



Native VLAN best Practices

- ▶ Best Practice is to configure the Native VLAN ID to VLAN 666 and to ensure that this VLAN is not used anywhere in the network.
- ▶ No ports should be assigned to the native VLAN
- ▶ An attacker who attempts to use the VLAN hopping attack will end up in a dead VLAN that has no hosts to leverage.



Native VLAN Configuration

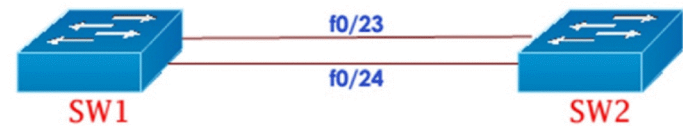
```
SWx(config)#vlan 999
```

```
SWx(config-vlan)#exit
```

```
SWx(config)#int f0/20
```

```
SWx(config-if)#switchport mode trunk
```

```
SWx(config-if)#switchport trunk native vlan 999
```



- For Cisco switches the Native VLAN ID must match on both end of the trunk.

This message appears when the native VLAN is mismatched on the two Cisco switches:

%CDP-4-NATIVE_VLAN_MISMATCH: Native VLAN mismatch discovered on FastEthernet0/20 (1), with SW1 FastEthernet0/20 (999).

Native VLAN -Verification

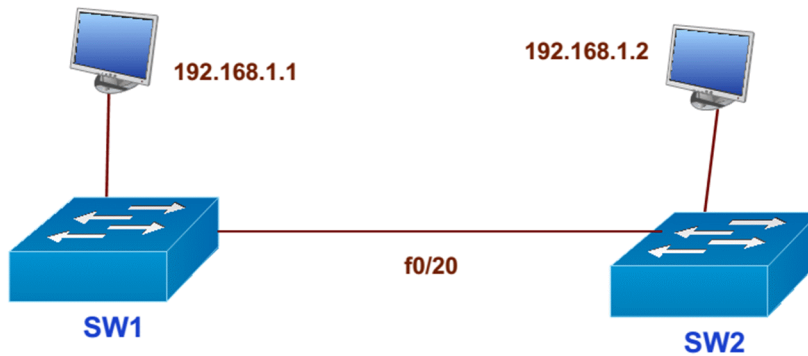
SW-1#sh interfaces trunk

Port	Mode	Encapsulation	Status	Native vlan
Fa0/20	on	802.1q	trunking	999

SW1#sh interfaces f0/20 switchport

```
Name: Fa0/20
Switchport: Enabled
Administrative Mode: dynamic auto
Operational Mode: trunk
Administrative Trunking Encapsulation: dot1q
Operational Trunking Encapsulation: dot1q
Negotiation of Trunking: On
Access Mode VLAN: 1 (default)
Trunking Native Mode VLAN: 999 (VLAN0999)
Voice VLAN: none
```

LAB: Native VLAN



TASK:

- Connect Devices and assign the IP addressing as per the diagram.
- Create vlan 999 on both switches.
- Configure f0/20 port as trunk link
- Ensure that vlan 999 should be native vlan on both trunks.
- Verify the connectivity between PC (192.168.1.1 and 192.168.1.2).

PC>ipconfig

FastEthernet0 Connection:(default port)
IP Address.....: 192.168.1.1
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 0.0.0.0

PC>ping 192.168.1.2

Pinging 192.168.1.2 with 32 bytes of data:
Reply from 192.168.1.2: bytes=32 time=12ms TTL=128
Reply from 192.168.1.2: bytes=32 time=0ms TTL=128
Reply from 192.168.1.2: bytes=32 time=0ms TTL=128
Reply from 192.168.1.2: bytes=32 time=0ms TTL=128

On SW1/SW2

```
SWx(config)#vlan 999  
SWx(config-vlan)#end
```

```
SWx(config)#int f0/20  
SWx(config-if)#switchport trunk encapsulation dot1q  
SWx(config-if)#switchport mode trunk
```

SW2#sh interfaces trunk

Port	Mode	Encapsulation	Status	Native vlan
Fa0/20	on	802.1q	trunking	1
Port	Vlans allowed on trunk			


```

Fa0/20    1-1005
Port      Vlans allowed and active in management domain
Fa0/20    1
Port      Vlans in spanning tree forwarding state and not pruned
Fa0/20    1

```

PC>ping 192.168.1.2

```

Pinging 192.168.1.2 with 32 bytes of data:
Reply from 192.168.1.2: bytes=32 time=1ms TTL=128
Reply from 192.168.1.2: bytes=32 time=0ms TTL=128
Reply from 192.168.1.2: bytes=32 time=0ms TTL=128
Reply from 192.168.1.2: bytes=32 time=0ms TTL=128

```

TASK: change native vlan to 999 on SW1 and verify connectivity

```

SW1(config)#int f0/20
SW1(config-if)#switchport trunk native vlan 999
SW1(config-if)#end

```

SW1#

%CDP-4-NATIVE_VLAN_MISMATCH: Native VLAN mismatch discovered on FastEthernet0/20 (999), with SW2 FastEthernet0/20 (1).

PC>ping 192.168.1.2

```

Pinging 192.168.1.2 with 32 bytes of data:
Request timed out.
Request timed out.
Request timed out.
Request timed out.

```

SW1#sh interfaces trunk

Port	Mode	Encapsulation	Status	Native vlan
Fa0/20	on	802.1q	trunking	999
Port	Vlans allowed on trunk			
Fa0/20	1-1005			
Port	Vlans allowed and active in management domain			
Fa0/20	1			
Port	Vlans in spanning tree forwarding state and not pruned			
Fa0/20	1			

SW1#sh interfaces f0/20 switchport

```

Name: Fa0/20
Switchport: Enabled
Administrative Mode: dynamic auto
Operational Mode: trunk

```

Administrative Trunking Encapsulation: dot1q
Operational Trunking Encapsulation: dot1q
Negotiation of Trunking: On
Access Mode VLAN: 1 (default)
Trunking Native Mode VLAN: 999 (VLAN0999)
Voice VLAN: none

SW2#sh interfaces trunk

Port	Mode	Encapsulation	Status	Native vlan
Fa0/20	on	802.1q	trunking	1
Port	Vlans allowed on trunk			
Fa0/20	1-1005			

Port	Vlans allowed and active in management domain
Fa0/20	1

Port	Vlans in spanning tree forwarding state and not pruned
Fa0/20	1

SW2(config)#int f0/20

SW2(config-if)#switchport trunk native vlan 999

SW2(config-if)#end

PC>ping 192.168.1.2

Pinging 192.168.1.2 with 32 bytes of data:

Reply from 192.168.1.2: bytes=32 time=1ms TTL=128

Reply from 192.168.1.2: bytes=32 time=0ms TTL=128

Reply from 192.168.1.2: bytes=32 time=0ms TTL=128

Reply from 192.168.1.2: bytes=32 time=0ms TTL=128

Extended VLAN

- ▶ Historically, Cisco Catalyst switches have supported only up to 1024 VLANs
- ▶ ISL uses 10-bit VLAN ID (upto 1024 Vlan)
- ▶ 802.1Q includes a 12-bit VLAN ID field (upto 4096 vlan)
- ▶ Cisco refers to the VLANs between 1025 and 4096 as extended-range VLANs.

Cisco Catalyst switches support extended-range VLANs under the following restrictions:



VTP cannot be used for VLAN management. (VTP must be configured in **transparent** mode or **off**)

```
SW7(config)#vtp mode server
Setting device to VTP Server mode for VLANs.
```

```
SW7(config)#vlan 4000
SW7(config-vlan)#name sales
SW7(config-vlan)#exit
% Failed to create VLANs 4000
Extended VLAN(s) not allowed in current VTP mode.
%Failed to commit extended VLAN(s) changes.
```

```
SW1(config)#vtp mode ?
client    Set the device to client mode.
off       Set the device to off mode.
server    Set the device to server mode.
transparent Set the device to transparent mode.
```


Only Ethernet VLANs are supported.

SW1#sh vlan

VLAN	Name	Status	Ports
1	default	active	Fa0/1, Fa0/2, Fa0/4, Fa0/5 Fa0/6, Fa0/7, Fa0/8, Fa0/9 Fa0/10, Fa0/11, Fa0/12, Fa0/13 Fa0/14, Fa0/15, Fa0/16, Fa0/17 Fa0/18, Fa0/19, Fa0/20, Fa0/21 Fa0/22, Gi0/1, Gi0/2
1002	fddi-default	act/unsup	
1003	trcrf-default	act/unsup	
1004	fddinet-default	act/unsup	
1005	trbrf-default	act/unsup	

SW7(config)#vtp mode transparent

Setting device to VTP Transparent mode for VLANs.

SW7(config)#vlan 4000

SW7(config-vlan)#name sales

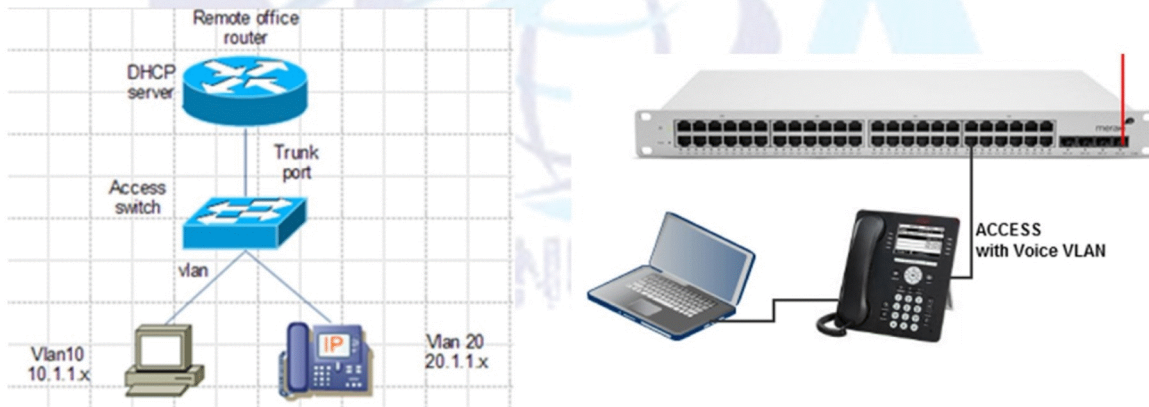
SW7(config-vlan)#exit

SW7#sh vlan

VLAN	Name	Status	Ports
1	default	active	Fa0/1, Fa0/2, Fa0/4, Fa0/5 Fa0/6, Fa0/7, Fa0/8, Fa0/9 Fa0/10, Fa0/11, Fa0/12, Fa0/13 Fa0/14, Fa0/15, Fa0/16, Fa0/17 Fa0/18, Fa0/19, Fa0/20, Fa0/21 Fa0/22, Gi0/1, Gi0/2
1002	fddi-default	act/unsup	
1003	trcrf-default	act/unsup	
1004	fddinet-default	act/unsup	
1005	trbrf-default	act/unsup	
4000	sales	active	

Voice VLAN

- ▶ voice VLAN feature enables access ports to carry IP voice traffic from an IP phone.
- ▶ switch can connect to IP Phone to carry IP voice traffic
- ▶ The Cisco IP Phone contains an integrated three-port 10/100 switch



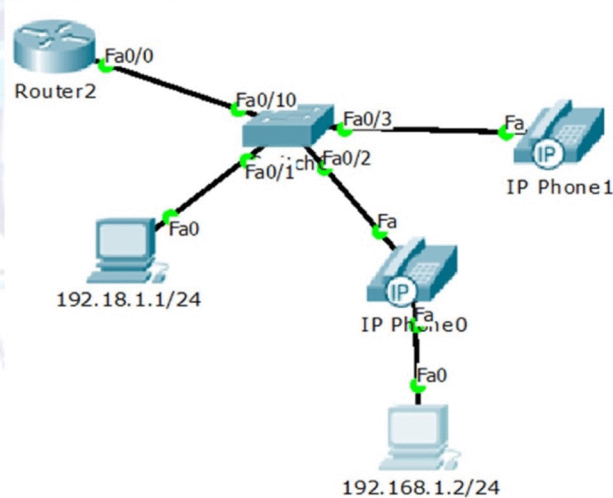
Default VLAN configuration :

- ▶ The voice VLAN feature is disabled by default.
- ▶ You should configure voice VLAN on switch access ports.
- ▶ The voice VLAN should be present and active on the switch for the IP phone to correctly communicate on the voice VLAN.
- ▶ Use the show vlan privileged EXEC command to see if the VLAN is present
- ▶ The Port Fast feature is automatically enabled when voice VLAN is configured.



Voice VLAN - Configuration

- ▶ Create VLAN 10 = DATA & VLAN 50 = VOICE
- ▶ Assign Ports connecting to PC to Data VLAN and IP phones to Voice VLAN

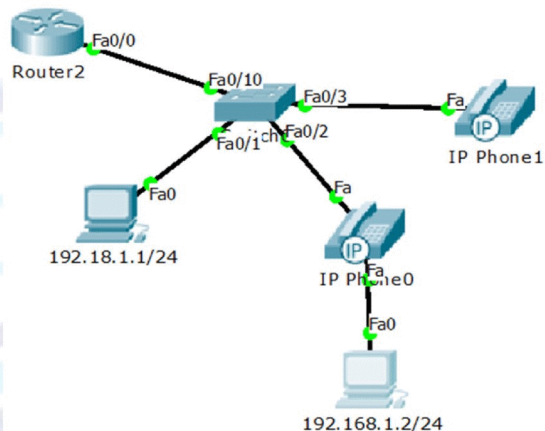


Voice VLAN - Configuration

VLAN 10 = DATA
VLAN 50 = VOICE

```
Switch(config)#vlan 10
Switch(config-vlan)#name DATA
Switch(config-vlan)#exit
```

```
Switch(config)#vlan 50
Switch(config-vlan)#name VOICE
Switch(config-vlan)#exit
```



Voice VLAN - Configuration

Assign Ports

- connecting to PC to Data VLAN
- IP phones to Voice VLAN

```
Switch(config)#int f0/1
```

```
Switch(config-if)# switchport mode access
```

```
Switch(config-if)# switchport access vlan 10
```

```
Switch(config-if)#exit
```

```
Switch(config)# int f0/3
```

```
Switch(config-if)# switchport mode access
```

```
Switch(config-if)#switchport voice vlan 50
```

```
Switch(config-if)#exit
```

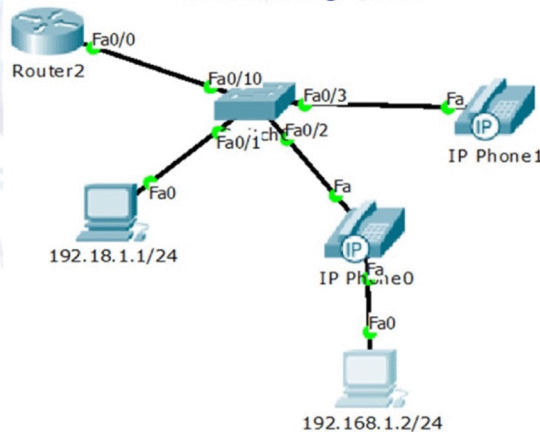
```
Switch(config)#int f0/2
```

```
Switch(config-if)#switchport mode access
```

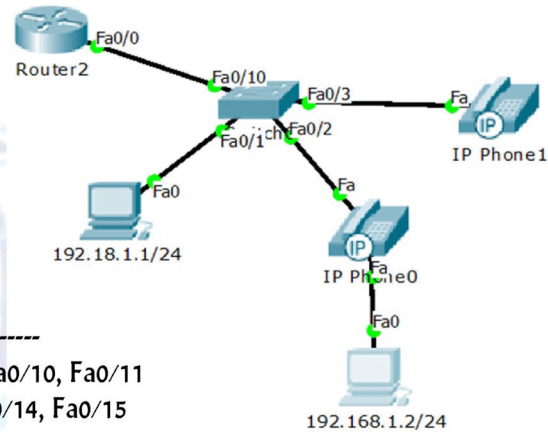
```
Switch(config-if)# switchport access vlan 10
```

```
Switch(config-if)# switchport voice vlan 50
```

```
Switch(config-if)#end
```



Voice VLAN - Verification



```
Switch#show vlan
```

VLAN Name	Status	Ports
1 default	active	Fa0/3, Fa0/9, Fa0/10, Fa0/11 Fa0/12, Fa0/13, Fa0/14, Fa0/15 Fa0/16, Fa0/17, Fa0/18, Fa0/19 Fa0/20, Fa0/21, Fa0/22, Fa0/23 Fa0/24, Gi0/1, Gi0/2
10 DATA	active	Fa0/1, Fa0/2
50 VOICE	active	Fa0/2, Fa0/3

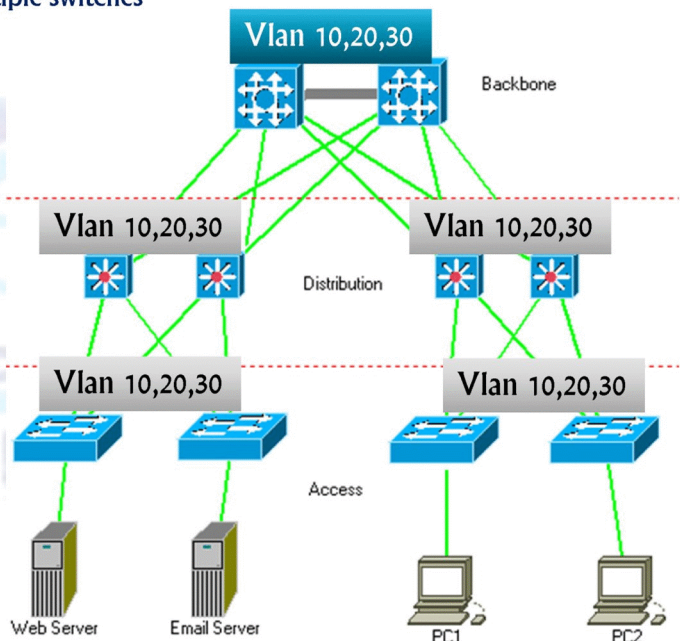
VTP

VLAN Trunking protocol

VLAN TRUNKING PROTOCOL

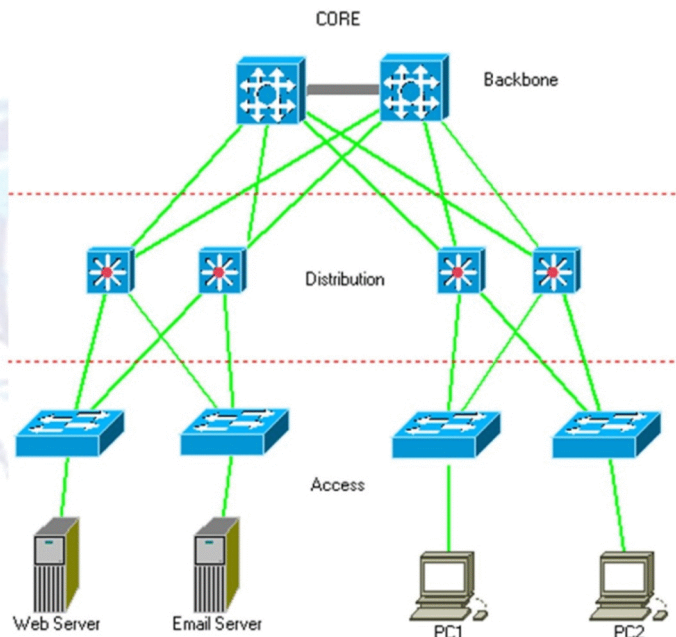
- used to share the VLAN configurations with multiple switches
- Maintain consistency throughout that network.
- VTP is a CISCO proprietary protocol

VTP manages the addition, deletion, and renaming of VLANs across the network from a central point of control



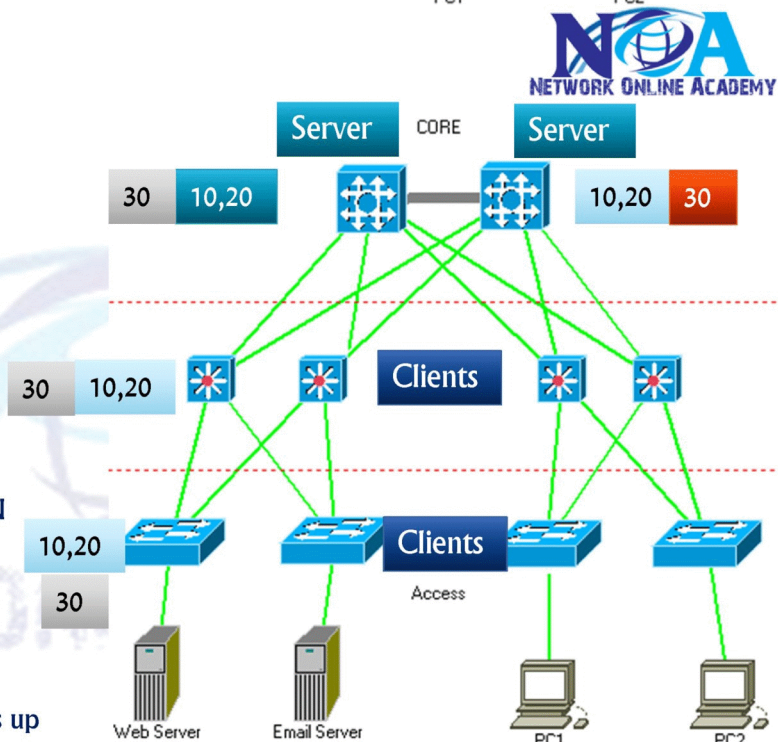
VTP MODES

1. Server Mode
2. Client mode
3. Transparent mode



Server Mode

- ❖ Default mode
- ❖ Creates, modifies, and deletes VLANs
- ❖ Synchronizes VLAN configurations
- ❖ Sends and forwards advertisements
- ❖ Saves configuration in NVRAM

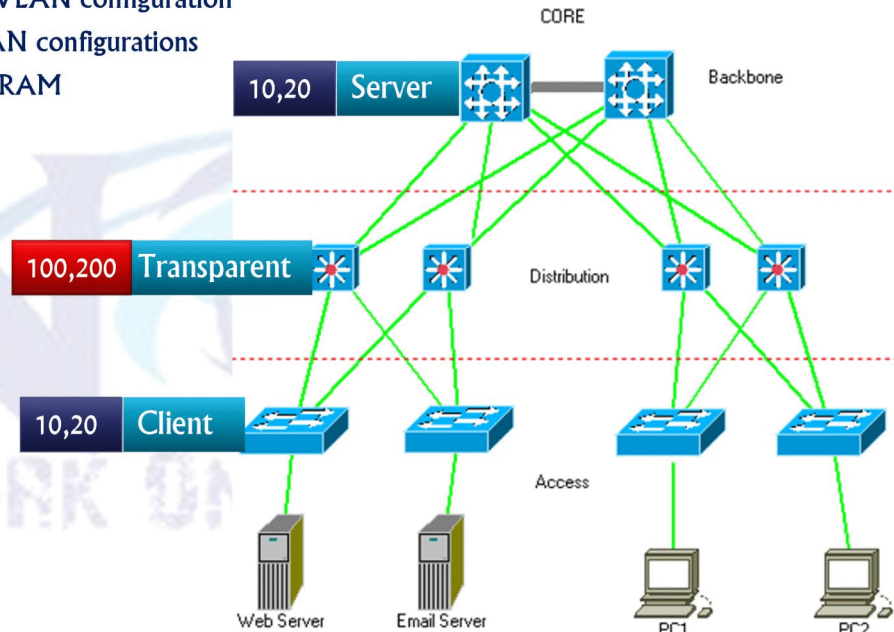


Client Mode

- ❖ cannot Add , Modify and Delete its VLAN configurations
- ❖ Synchronizes VLAN configurations
- ❖ Forwards advertisements
- ❖ Doesn't store its VLAN configuration
- ❖ learns it from the server every time it boots up

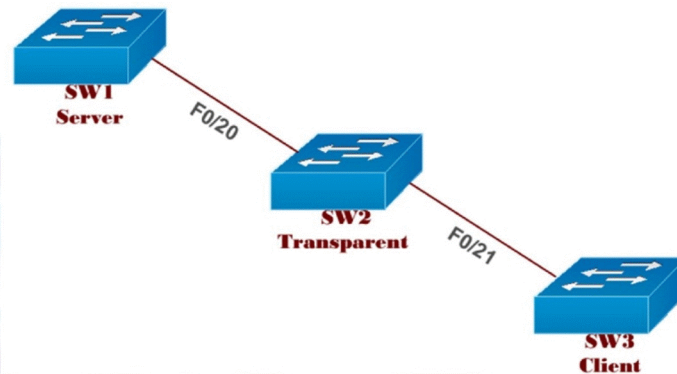
Transparent Mode

- ❖ Add , Modify and Delete VLAN configuration
- ❖ Does not synchronize VLAN configurations
- ❖ Saves configuration in NVRAM
- ❖ **Forwards advertisements**



VTP - configuration

1. Configure Trunking
2. Configure VTP Domain
3. Create Vlan server/Transparent
4. Verify



NOTE :

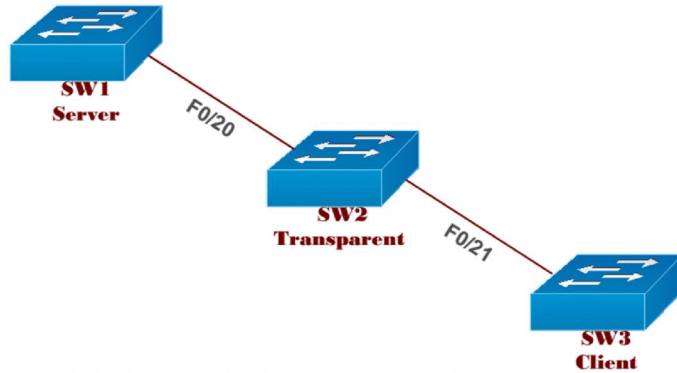
- All links must be configured as trunks.
- Information will be passed only if switches connected with Fast Ethernet or higher ports.

VTP - configuration

```
SW-1(config)#int f0/20
SW-1(config-if)#switchport mode trunk
SW-1(config-if)#switchport trunk encapsulation dot1q

SW2(config)#int range fa0/20 - 21
SW-2(config-if)#switchport mode trunk
SW-2(config-if)#switchport trunk encapsulation dot1q

SW3(config)#int f0/21
SW-3(config-if)#switchport mode trunk
SW-3(config-if)#switchport trunk encapsulation dot1q
```



SW2#sh interfaces trunk

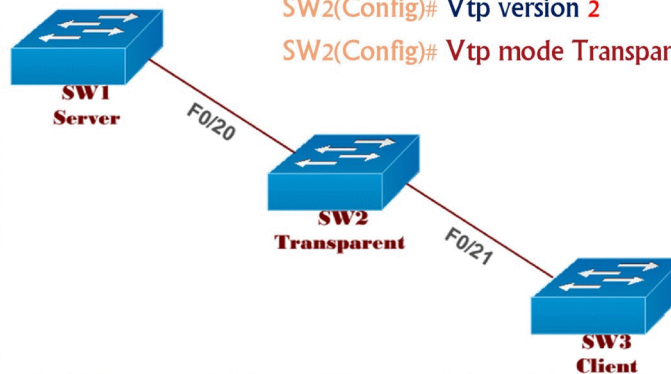
Port	Mode	Encapsulation	Status	Native vlan
Fa0/20	on	802.1q	trunking	1
Fa0/21	on	802.1q	trunking	1

VTP - configuration

```
SW1(Config)# VTP domain CCIE
SW1(Config)# Vtp password cisco123
SW1(Config)# Vtp version 2
SW1(Config)# Vtp mode server
```

```
SW2(Config)# VTP domain CCIE
SW2(Config)# Vtp password cisco123
SW2(Config)# Vtp version 2
SW2(Config)# Vtp mode Transparent
```

```
SW3(Config)# VTP domain CCIE
SW3(Config)# Vtp password cisco123
SW3(Config)# Vtp version 2
SW3(Config)# Vtp mode Client
```

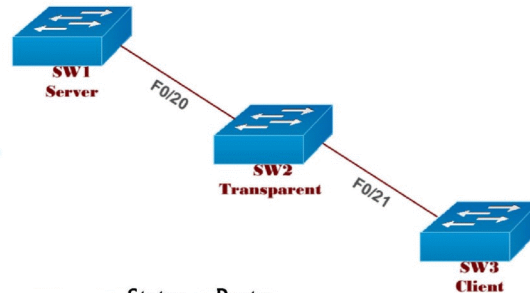


Note:

- Domain name must match & Case sensitive.
- VTP password & version must match.
- VTP once enabled uses version 1 only

VTP - Verification

```
SW-1(config)#vlan 10
SW-1(config-vlan)#vlan 20
SW-1(config-vlan)#vlan 30
```

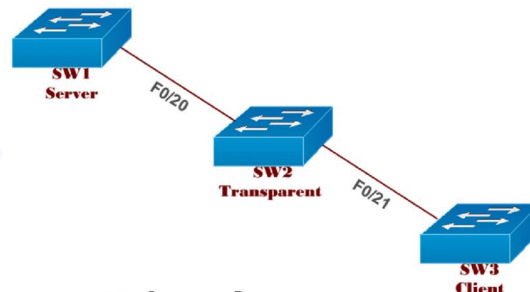


```
SW-3#sh vlan
```

VLAN Name	Status	Ports
1 default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Fa0/11, Fa0/12 Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18, Fa0/19, Fa0/20 Fa0/22, Fa0/23, Fa0/24, Gig1/1 Gig1/2
10 VLAN0010	active	
20 VLAN0020	active	
30 VLAN0030	active	

VTP - Verification

```
Sw-2(config)#vlan 100
Sw-2(config-vlan)#vlan 200
Sw-2(config-vlan)#vlan 300
```



```
SW-3#sh vlan
```

VLAN Name	Status	Ports
1 default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Fa0/11, Fa0/12 Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18, Fa0/19, Fa0/20 Fa0/22, Fa0/23, Fa0/24, Gig1/1 Gig1/2
10 VLAN0010	active	
20 VLAN0020	active	
30 VLAN0030	active	

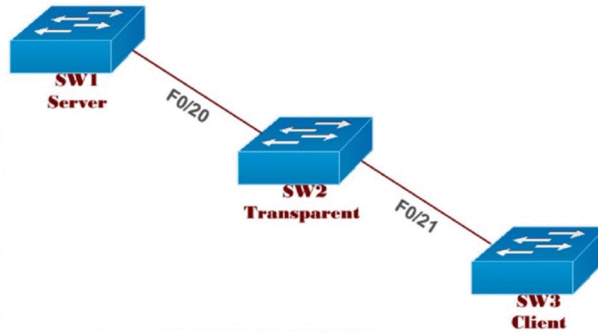
VTP - Verification

SW-1#sh vtp password

VTP Password: cisco123

SW-1#sh vtp status

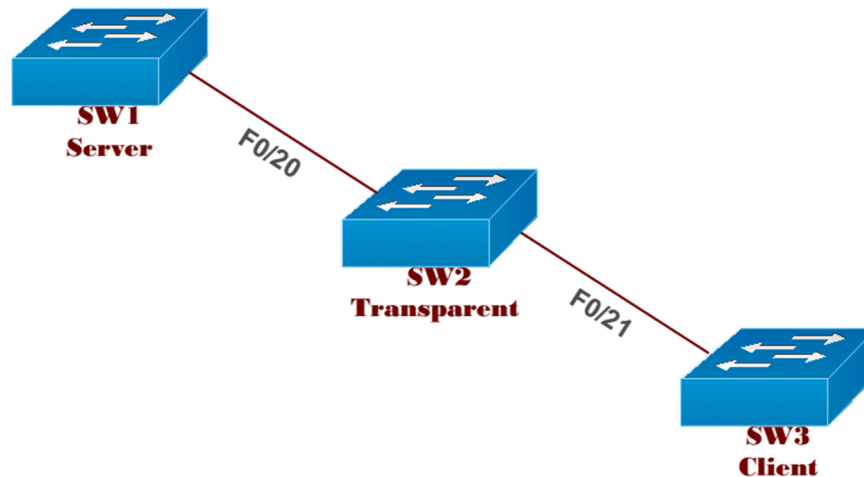
VTP Version : 2
Configuration Revision : 4
Maximum VLANs supported locally : 255
Number of existing VLANs : 8
VTP Operating Mode : Server
VTP Domain Name : CCIE
VTP Pruning Mode : Disabled
VTP V2 Mode : Enabled
VTP Traps Generation : Disabled
MD5 digest : 0xD1 0xBE 0x9B 0xAB 0xDD 0xFF 0x2F 0x8E
Configuration last modified by 0.0.0.0 at 3-1-93 00:36:37
Local updater ID is 0.0.0.0 (no valid interface found)



VTP Versions

VTP version 1	VTP Version 2
Supports only one VTP domain	Support multiple VTP domain
Check for domain name (if matches then only forward VTP messages)	Not check for Domain name sending advertisements (match to synchronize database)
More consistent check (add more overhead)	Check for consistency ,whenever new information is added
No Support for Token ring VLAN	Support for Token ring VLAN

LAB: VTP



TASK:

- 1) Configure the links between Switches as Trunks. (vtp advertisements are send only on trunk ports)
- 2) Configure VTP on all switches as per the given modes in the Diagram above.
- 3) To verify VTP
 - a. Create vlans on server and verify on client and transparent switch
 - b. Create vlans on transparent switch and verify on client and server

On SW1 (SERVER)

```
SW-1(config)#int f0/20
SW-1(config-if)#switchport mode trunk
SW-1(config-if)#switchport trunk encapsulation dot1q
```

SW2 (TRANSPARENT)

```
SW2(config)#int range fa0/20 - 21
SW-2(config-if)#switchport mode trunk
SW-2(config-if)#switchport trunk encapsulation dot1q
```

SW3 (CLIENT)

```
SW3(config)#int f0/21
SW-3(config-if)#switchport mode trunk
SW-3(config-if)#switchport trunk encapsulation dot1q
```

```
SW1#sh interfaces trunk
```

Port	Mode	Encapsulation	Status	Native vlan
Fa0/20	on	802.1q	trunking	1

SW2#sh interfaces trunk

Port	Mode	Encapsulation	Status	Native vlan
Fa0/20	on	802.1q	trunking	1
Fa0/21	on	802.1q	trunking	1

SW-3#sh interfaces trunk

Port	Mode	Encapsulation	Status	Native vlan
Fa0/21	on	802.1q	trunking	1

TASK:

- Configure VTP on all switches as per the given modes in the Diagram above.
- (SW1 –SERVER, SW2 – TRANSPARENT, SW3 – CLIENT)

Make Sure that Domain name (case-sensitive) / password / version must match on all switches for sending and receiving VTP Messages

SW1

```
SW-1(config)#vtp domain CCNP
SW-1(config)#vtp password cisco123
SW-1(config)#vtp version 2
SW-1(config)#vtp mode server
```

SW2

```
SW-2(config)#vtp domain CCNP
SW-2(config)#vtp password cisco123
SW-2(config)#vtp version 2
SW-2(config)#vtp mode transparent
```

SW3

```
SW-1(config)#vtp domain CCNP
SW-1(config)#vtp password cisco123
SW-1(config)#vtp version 2
SW-1(config)#vtp mode client
```

SW1#sh vtp status

```
VTP Version : 2
Configuration Revision : 2
Maximum VLANs supported locally : 255
Number of existing VLANs : 5
VTP Operating Mode : Server
VTP Domain Name : CCNP
VTP Pruning Mode : Disabled
VTP V2 Mode : Enabled
VTP Traps Generation : Disabled
MD5 digest : 0x86 0x22 0x83 0x8E 0x23 0xA8 0x06 0xCC
```


Configuration last modified by 0.0.0.0 at 3-1-93 00:07:33
Local updater ID is 0.0.0.0 (no valid interface found)

SW1#sh vtp password

VTP Password: cisco123

The current VTP parameters for a management domain can be displayed using the show vtp status command

SW-3#sh vtp status

VTP Version : 2

Configuration Revision : 2

Maximum VLANs supported locally : 255

Number of existing VLANs : 5

VTP Operating Mode : Client

VTP Domain Name : CCNP

VTP Pruning Mode : Disabled

VTP V2 Mode : Enabled

VTP Traps Generation : Disabled

MD5 digest : 0x86 0x22 0x83 0x8E 0x23 0xA8 0x06 0xCC

Configuration last modified by 0.0.0.0 at 3-1-93 00:07

To verify VTP

- Create vlans on server and verify on client and transparent switch
- Create vlans on transparent switch and verify on client and server

SW1

SW-1(config)#vlan 10

SW-1(config-vlan)#vlan 20

SW-1(config-vlan)#vlan 30

SW-1(config-vlan)#vlan 40

SW-1(config-vlan)#name sales

SW-1(config-vlan)#vlan 50

SW-1(config-vlan)#name marketing

R1#sh vlan

VLAN Name	Status	Ports
1 default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Fa0/11, Fa0/12 Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18, Fa0/19, Fa0/21

```

Fa0/22, Fa0/23, Fa0/24, Gig1/1
Gig1/2
10 VLAN0010 active
20 VLAN0020 active
30 VLAN0030 active
40 sales active
50 marketing active
1002 fddi-default act/unsup
1003 token-ring-default act/unsup
1004 fddinet-default act/unsup
1005 trnet-default act/unsup

```

SW-3#sh vlan

```

VLAN Name                Status  Ports
-----
1  default                active  Fa0/1, Fa0/2, Fa0/3, Fa0/4
                             Fa0/5, Fa0/6, Fa0/7, Fa0/8
                             Fa0/9, Fa0/10, Fa0/11, Fa0/12
                             Fa0/13, Fa0/14, Fa0/15, Fa0/16
                             Fa0/17, Fa0/18, Fa0/19, Fa0/20
                             Fa0/22, Fa0/23, Fa0/24, Gig1/1
                             Gig1/2
10 VLAN0010                active
20 VLAN0020                active
30 VLAN0030                active
40 sales                  active
50 marketing              active

```

Sw-2#sh vlan

```

VLAN Name                Status  Ports
-----
1  default                active  Fa0/1, Fa0/2, Fa0/3, Fa0/4
                             Fa0/5, Fa0/6, Fa0/7, Fa0/8
                             Fa0/9, Fa0/10, Fa0/11, Fa0/12
                             Fa0/13, Fa0/14, Fa0/15, Fa0/16
                             Fa0/17, Fa0/18, Fa0/19, Fa0/22
                             Fa0/23, Fa0/24, Gig1/1, Gig1/2
1002 fddi-default          act/unsup
1003 token-ring-default    act/unsup
1004 fddinet-default        act/unsup
1  et-default              act/unsup

```

You don't see any vlan on the transparent mode switch as the transparent will not synchronize the vlan information from any other Switches but still forward the Vlan information.

```

Sw-2(config)#vlan 100
Sw-2(config-vlan)#vlan 200
Sw-2(config-vlan)#vlan 300
Sw-2(config-vlan)#end

```

SW2 #sh vlan

VLAN Name	Status	Ports
1 default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Fa0/11, Fa0/12 Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18, Fa0/19, Fa0/22 Fa0/23, Fa0/24
100 VLAN0100	active	
200 VLAN0200	active	
300 VLAN0300	active	
1002 fddi-default	act/unsup	

Sw1#sh vlan

VLAN Name	Status	Ports
1 default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Fa0/11, Fa0/12 Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18, Fa0/19, Fa0/21 Fa0/22, Fa0/23, Fa0/24, Gig1/1 Gig1/2
10 VLAN0010	active	
20 VLAN0020	active	
30 VLAN0030	active	
40 VLAN0040	active	
1002 fddi-default	act/unsup	
1003 token-ring-default	act/unsup	
1004 fddinet-default	act/unsup	
1005 trnet-default	act/unsup	

SW3 # sh vlan

VLAN Name	Status	Ports
1 default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4

	Fa0/5, Fa0/6, Fa0/7, Fa0/8
	Fa0/9, Fa0/10, Fa0/11, Fa0/12
	Fa0/13, Fa0/14, Fa0/15, Fa0/16
	Fa0/17, Fa0/18, Fa0/19, Fa0/21
	Fa0/22, Fa0/23, Fa0/24, Gig1/1
	Gig1/2
10	VLAN0010 active
20	VLAN0020 active
30	VLAN0030 active
40	VLAN0040 active
1002	fddi-default act/unsup
1003	token-ring-default act/unsup
1004	fddinet-default act/unsup
1005	trnet-default act/unsup

- You can see the vlans created on the transparent switch are not present in any of the other switches (SW1 or SW3) because the switch in transparent mode will not synchronize the vlan information
- Revision number for switches in the transparent mode will be always ZERO.

Sw-2#sh vtp status

```

VTP Version           : 2
Configuration Revision : 0
Maximum VLANs supported locally : 255
Number of existing VLANs : 8
VTP Operating Mode    : Transparent
VTP Domain Name       : CCNP
VTP Pruning Mode      : Disabled
VTP V2 Mode           : Enabled
VTP Traps Generation  : Disabled
MD5 digest            : 0xB7 0x9D 0xA5 0xEF 0xDE 0x56 0xC5 0xCF
Configuration last modified by 0.0.0.0 at 3-1-93 00:07

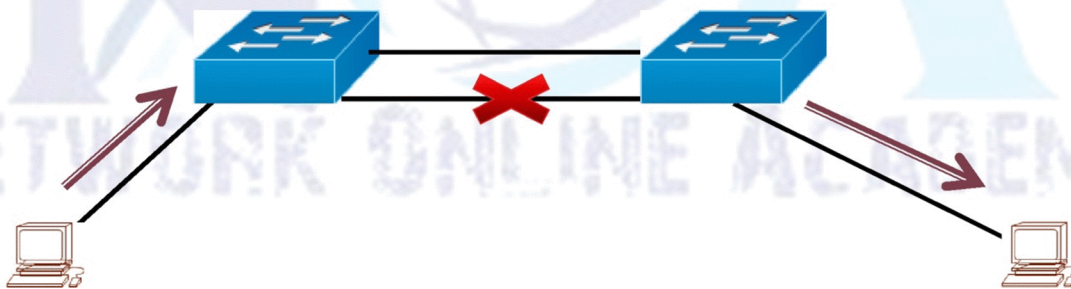
```

Spanning-tree protocol

Bridging loops



Redundant link between switches provides redundancy.

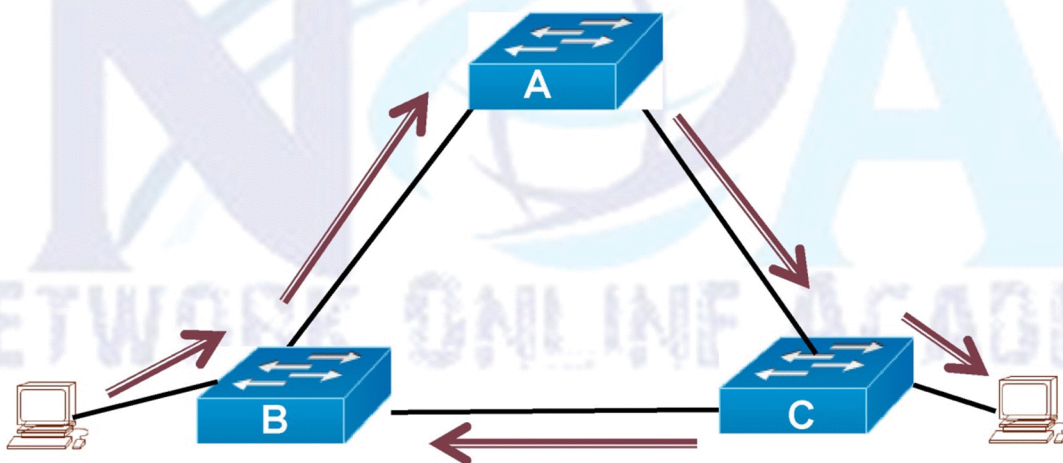
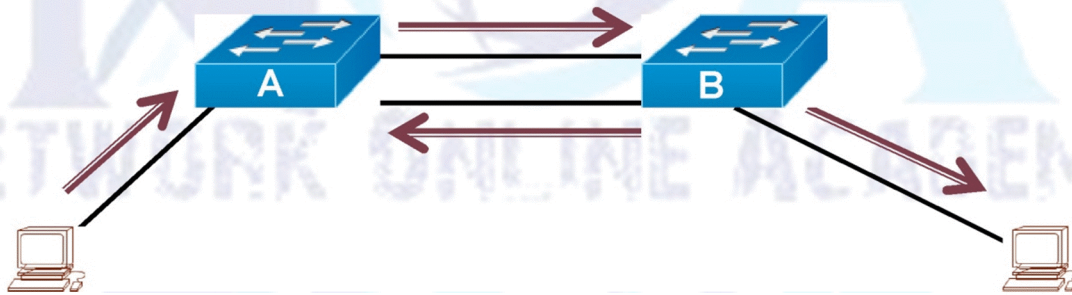


Bridging loops

Redundant link between switches provides redundancy.

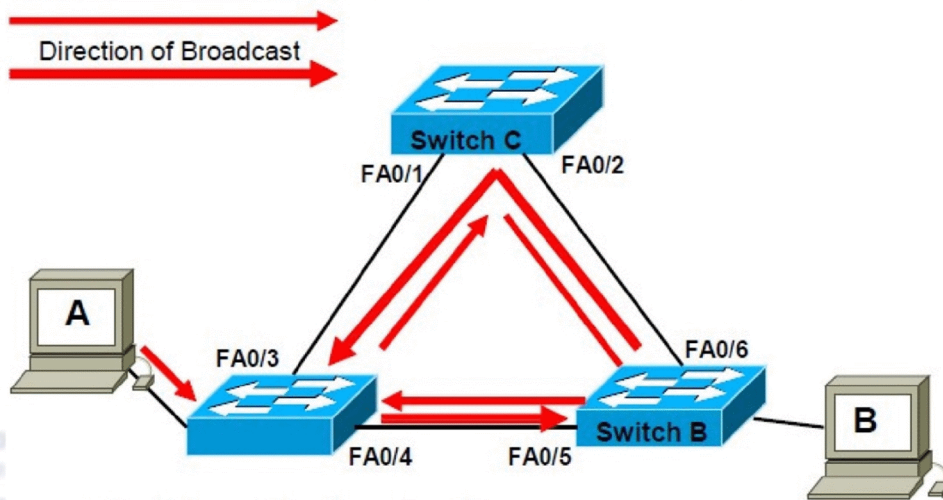
Also possibility to create loops when switches do broadcasts.

1. Broadcast storms
2. Mac-table instability
3. Multiple frame transmissions



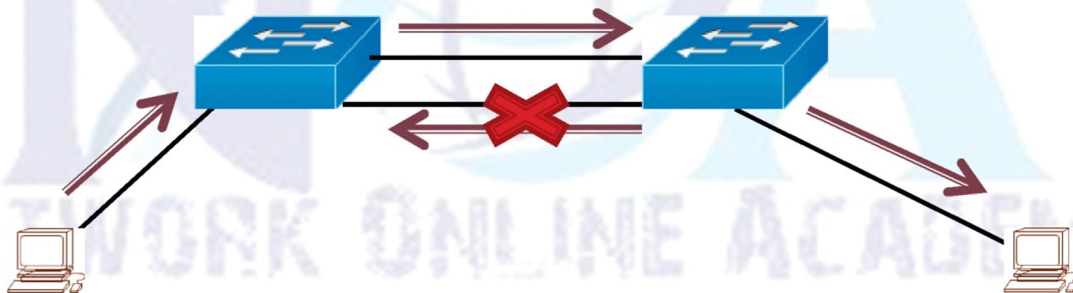
Bridging loops

Broadcast Storm



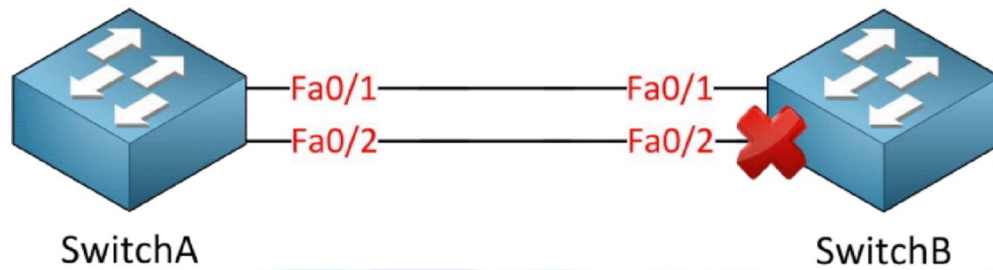
Bridging loops (solution)

- ▶ Only one link between switches (no redundancy)
- ▶ Shutdown extra link temporarily
 - Manually (shutdown command)
 - Automatically block extra links (done by STP)



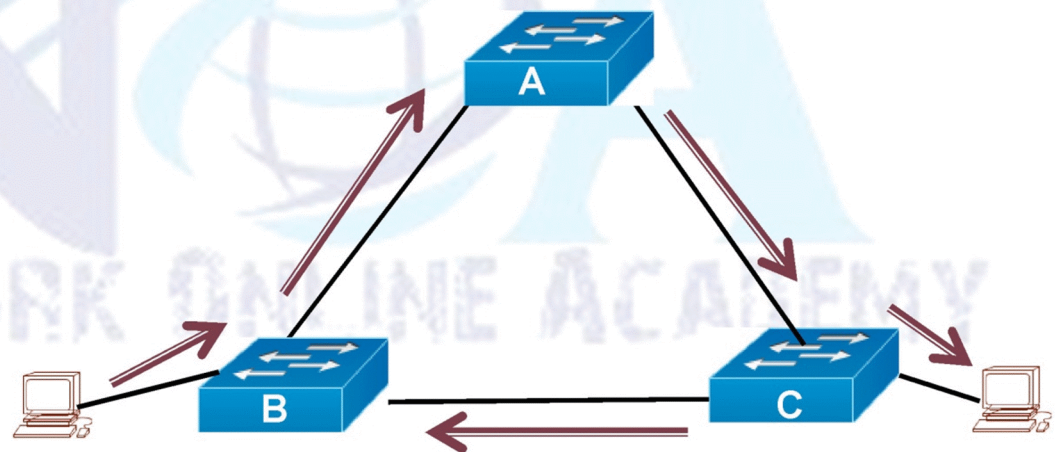
Spanning-tree Protocol

- ▶ STP stop the loops which occurs when you have multiple links between switches
- ▶ STP stops avoiding Broadcast Storms, Multiple Frame Copies & Database instability.
- ▶ STP is a open standard (IEEE 802.1D)
- ▶ STP is enabled by default on all Cisco Catalyst switches



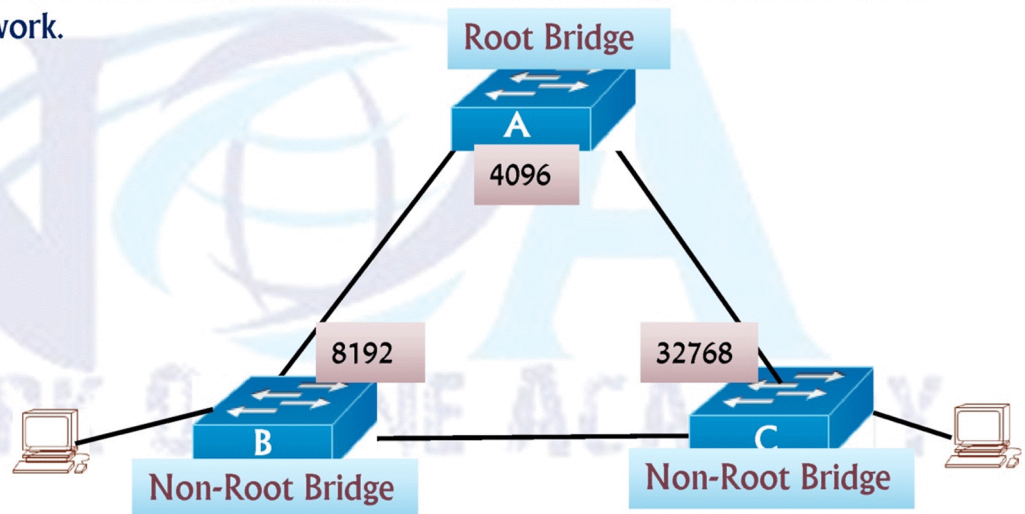
How STP works

1. Selecting the Root Bridge
2. Selecting the Root Port
3. Selecting Designated port & Non Designated port



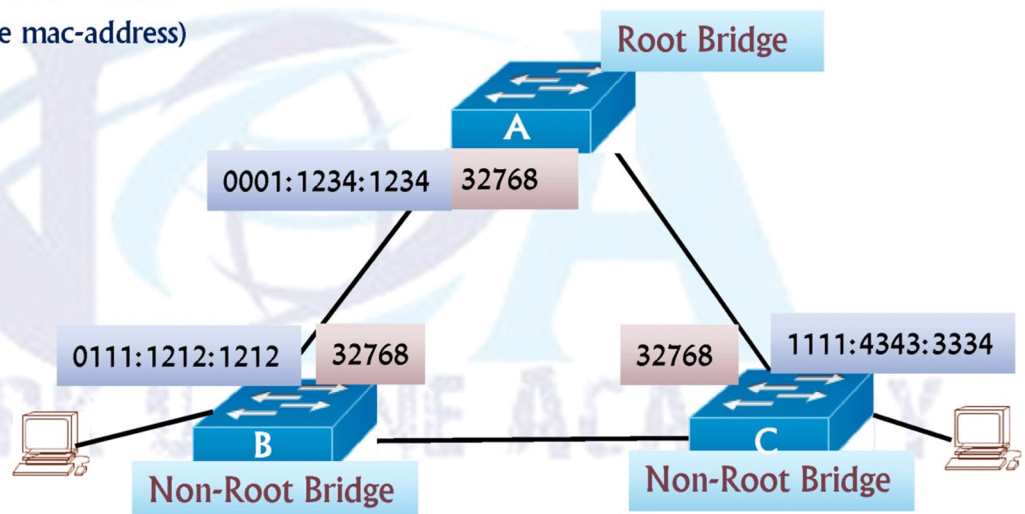
1) Selecting the Root Bridge

- ▶ The bridge with the Best (Lowest) Bridge ID.
- ▶ Bridge ID = Priority + MAC address of the switch (least is best)
- ▶ Out of all the switches in the network, one is elected as a root bridge that becomes the focal point in the network.



1) Selecting the Root Bridge

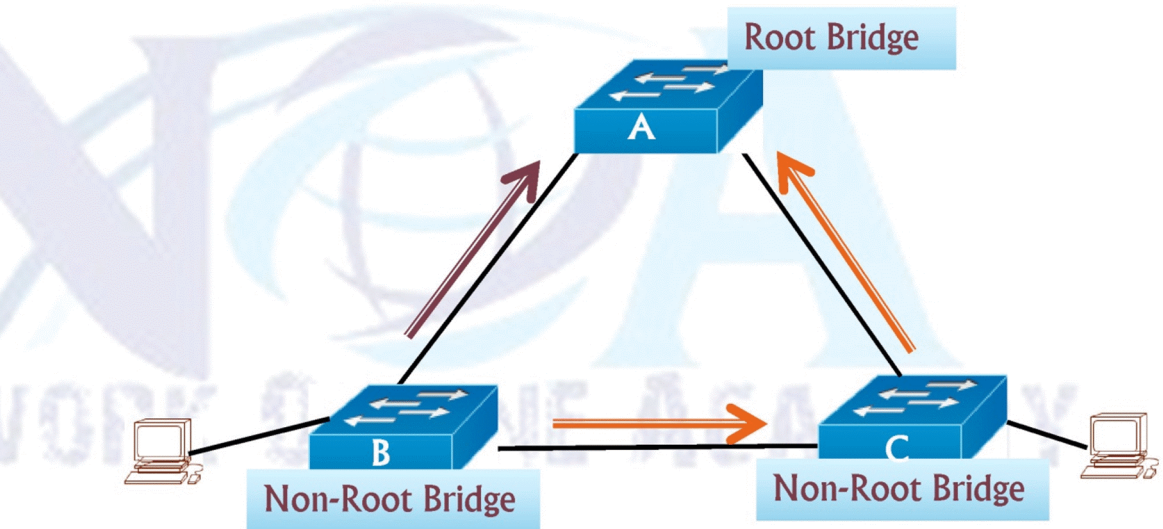
- ▶ The bridge with the Best (Lowest) Bridge ID.
- ▶ Bridge ID = Priority + MAC address of the switch (least is best)
- ▶ Default priority on cisco switches = 32768
- ▶ Show version (to verify base mac-address)



- ▶ Every LAN will have only one Root Bridge
- ▶ and all the remaining switches will be considered as Non-root Bridges.

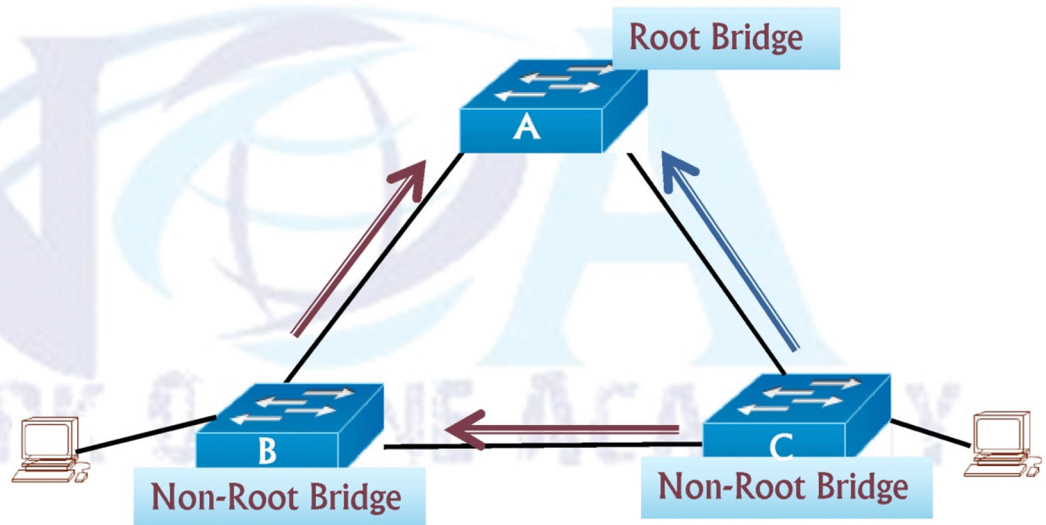
2) Selecting the Root Port:

- ▶ Shortest path to the Root bridge
- ▶ Every Non-root Bridge looks the best way to go Root-bridge



2) Selecting the Root Port:

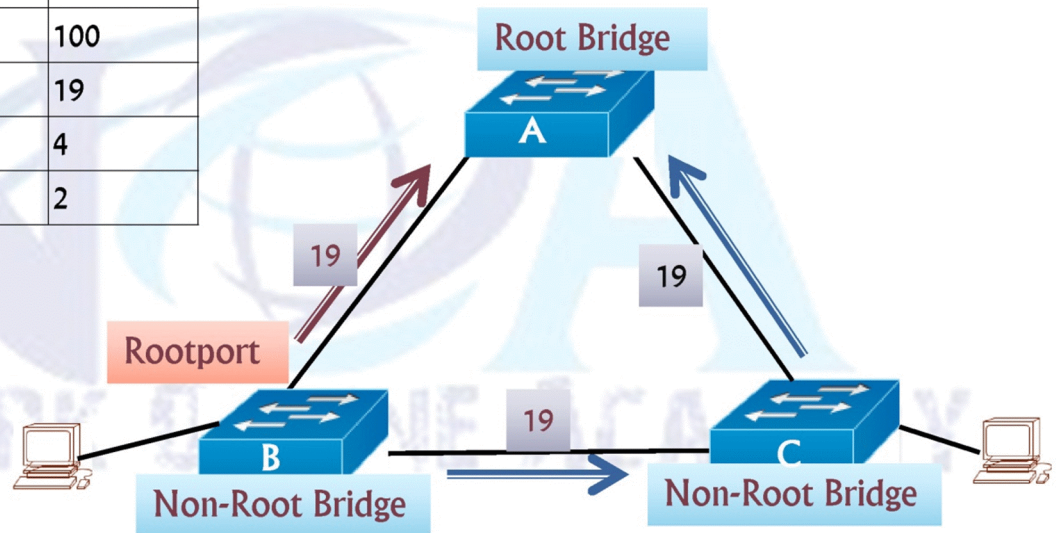
- ▶ Shortest path to the Root bridge
- ▶ Every Non-root Bridge looks the best way to go Root-bridge



Root port selection based on Cost

- ▶ least cost (Speed)

Bandwidth	Port Cost
10 Mbps	100
100 Mbps	19
1-Gigabit Ethernet	4
10-Gigabit Ethernet	2

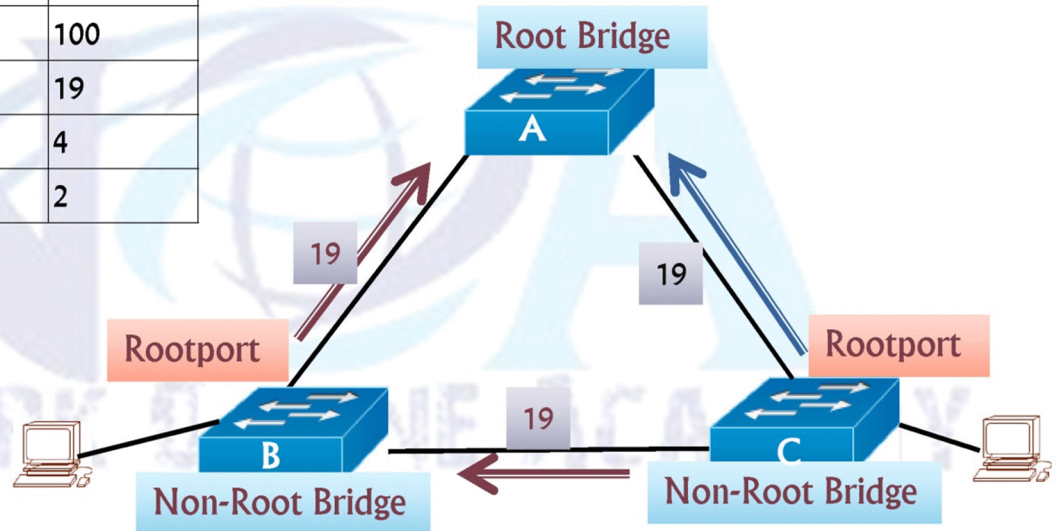


- ▶ For every non-root bridge there is only one root port.

Root port selection based on Cost

- ▶ least cost (Speed)

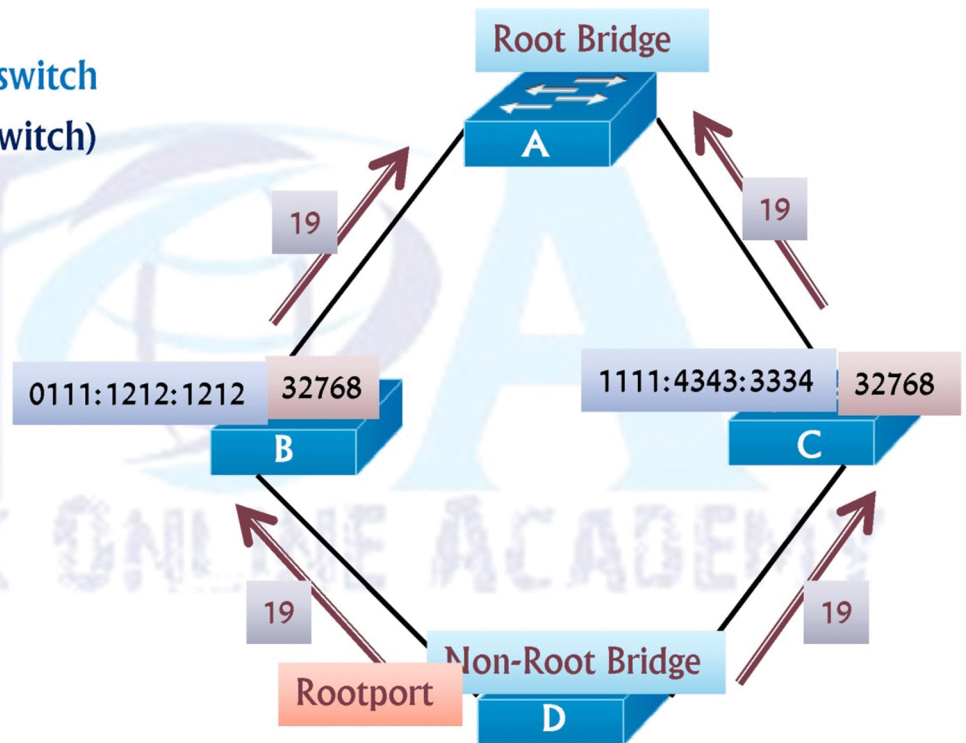
Bandwidth	Port Cost
10 Mbps	100
100 Mbps	19
1-Gigabit Ethernet	4
10-Gigabit Ethernet	2



- ▶ For every non-root bridge there is only one root port.

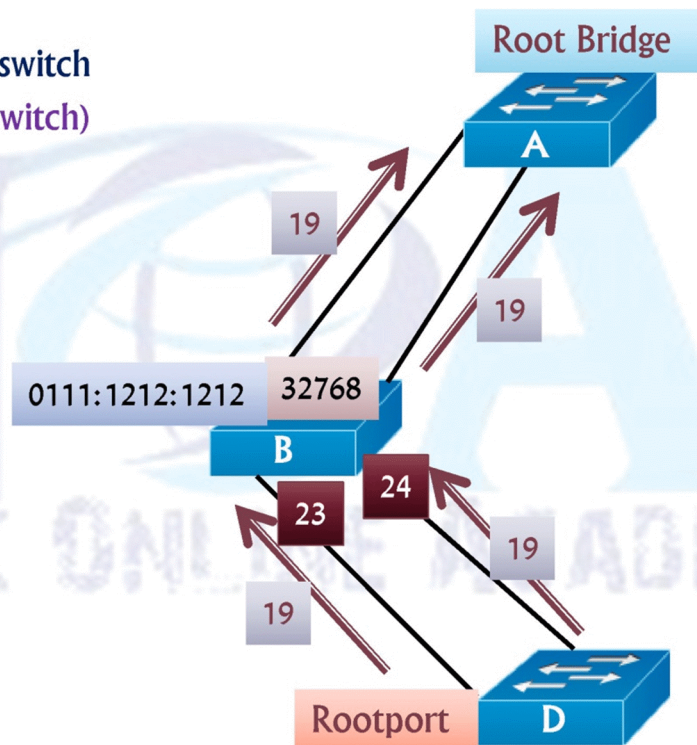
Root port selection

- ▶ least cost (Speed)
- ▶ Bridge-ID of forwarding switch
- ▶ Least port (forwarding switch)



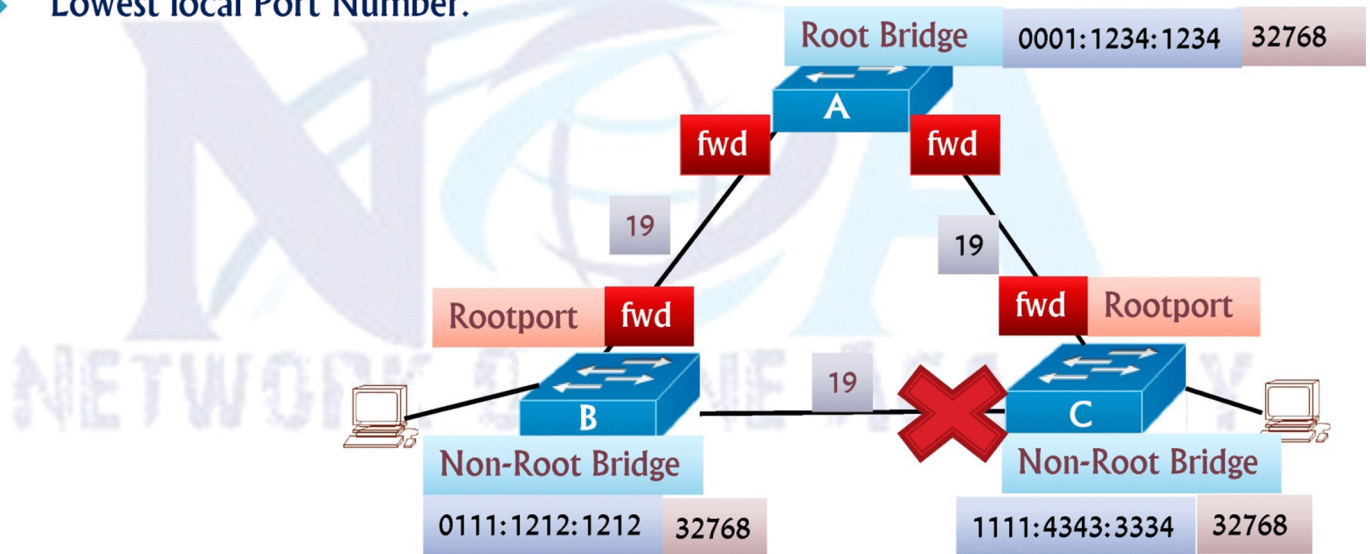
Root port selection

- least cost (Speed)
- Bridge-ID of forwarding switch
- Least port (forwarding switch)

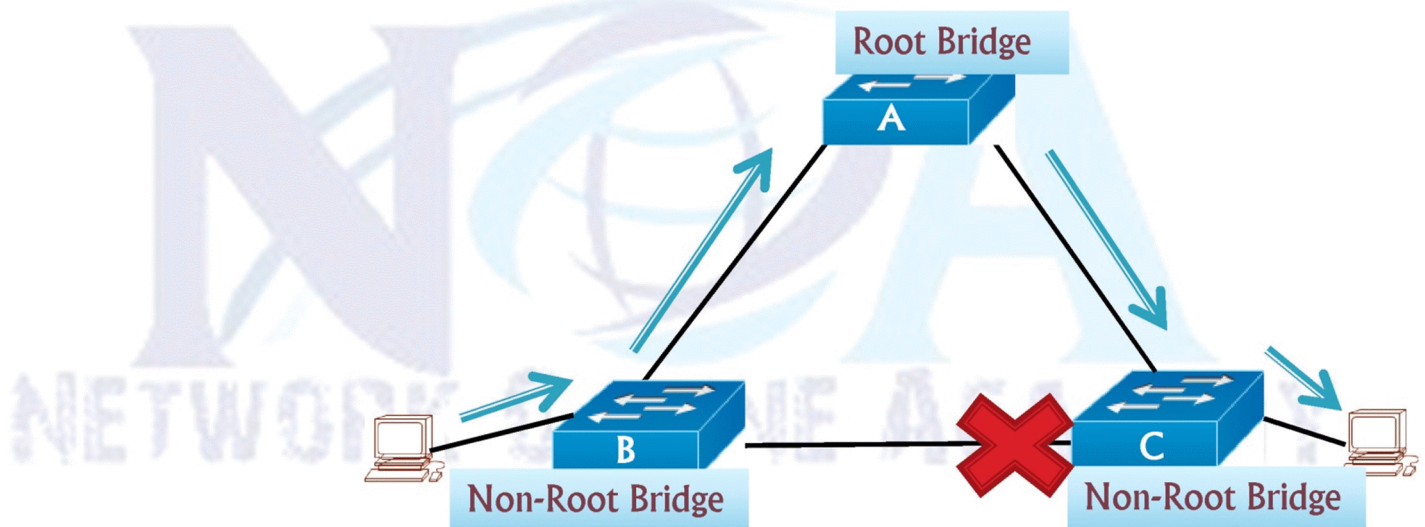


3) Selecting Designated port & Non Designated port

- ▶ least cost (Speed)
- ▶ The least local Switch ID.
- ▶ Lowest local Port Number.

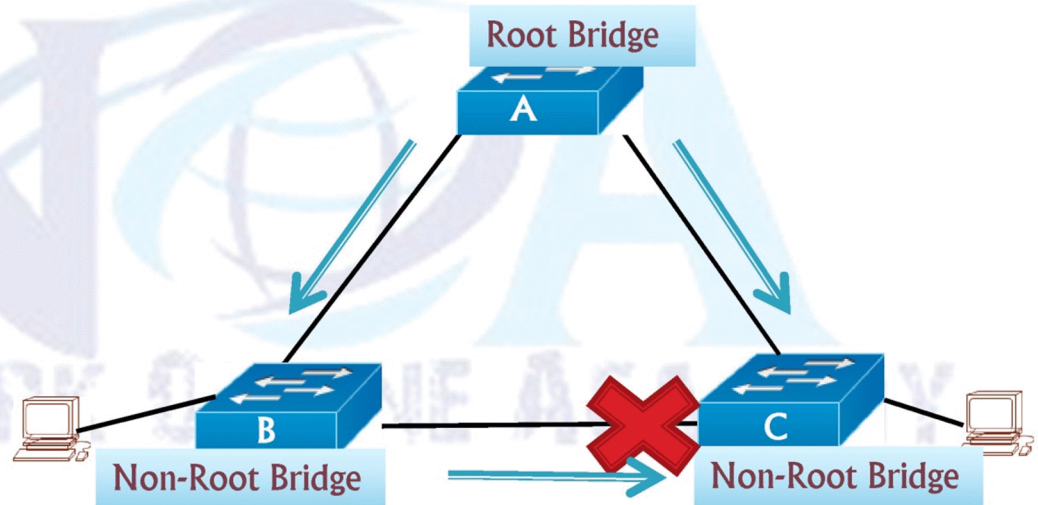


Root bridge – central switch all the traffic forwarded.



BPDUs

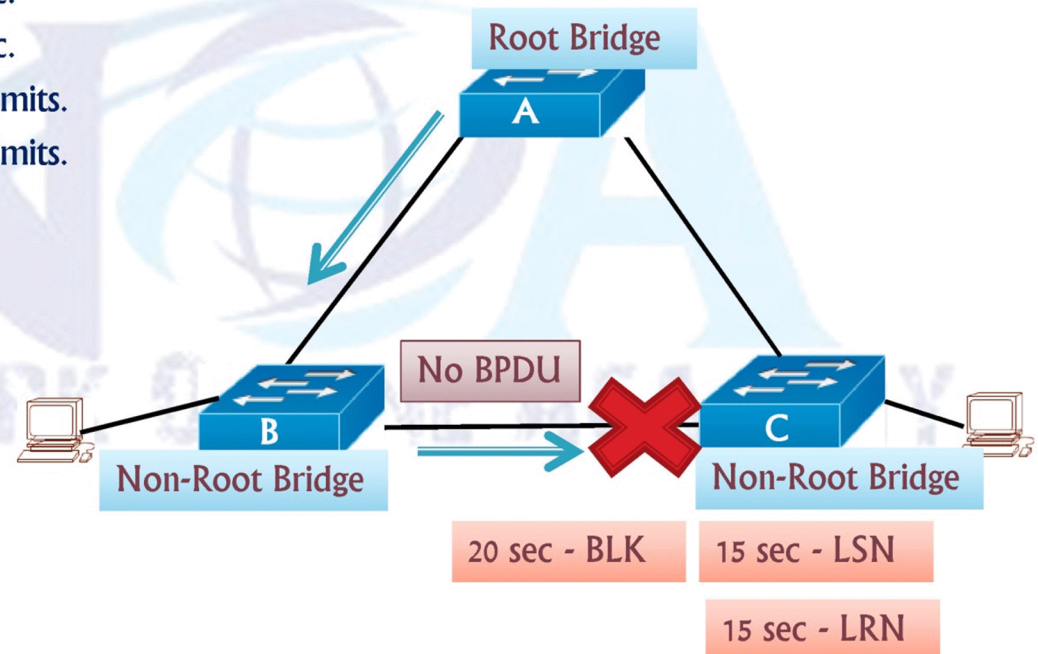
- ▶ All switches exchange information through what is called as Bridge Protocol Data Units (BPDUs)
- ▶ BPDUs are sent every 2 sec and dead = 20 sec
- ▶ A BPDU contains information regarding ports, switches, port priority and addresses.



STP Convergence

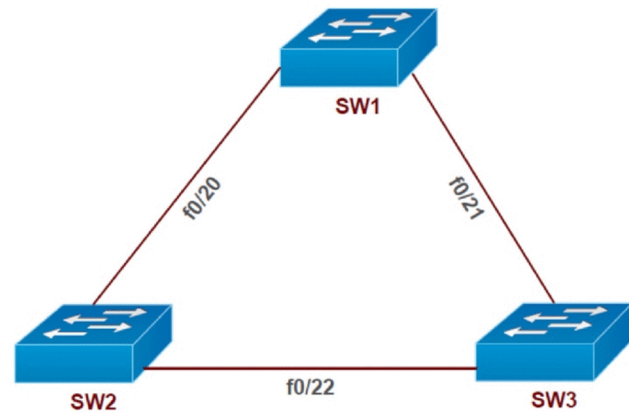
STP port states

- ▶ Blocking 20 Sec or No Limits.
- ▶ Listening 15 Sec.
- ▶ Learning 15 Sec.
- ▶ Forwarding No Limits.
- ▶ Disable No Limits.

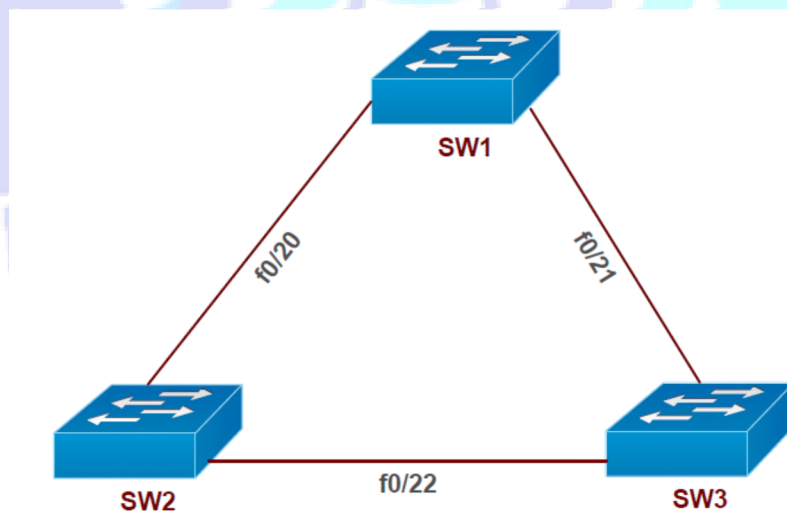


Lab : verifying spanning-tree

Show Spanning-tree



LAB: VERIFYING SPANNING-TREE



TASK: Find Root Bridge and alternate port (BLK)

Sw1#sh spanning-tree

VLAN0001

Spanning tree enabled protocol ieee

Root ID Priority 32769

Address 0007.ECCD.AC82

Cost 19

Port 20(FastEthernet0/20)

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32769 (priority 32768 sys-id-ext 1)
Address 00D0.580D.2EE0
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 20

Interface	Role	Sts	Cost	Prio.	Nbr	Type
Fa0/20	Root	FWD	19	128.20		P2p
Fa0/21	Desg	FWD	19	128.21		P2p

SW2#sh spanning-tree

VLAN0001

Spanning tree enabled protocol ieee

Root ID Priority 32769

Address 0007.ECCD.AC82

This bridge is the root

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32769 (priority 32768 sys-id-ext 1)

Address 0007.ECCD.AC82

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Aging Time 20

Interface	Role	Sts	Cost	Prio.	Nbr	Type
Fa0/20	Desg	FWD	19	128.20		P2p
Fa0/22	Desg	FWD	19	128.22		P2p

SW3#sh spanning-tree

VLAN0001

Spanning tree enabled protocol ieee

Root ID Priority 32769

Address 0007.ECCD.AC82

Cost 19

Port 22(FastEthernet0/22)

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32769 (priority 32768 sys-id-ext 1)

Address 00D0.971E.4EAE

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Aging Time 20

Interface	Role	Sts	Cost	Prio.	Nbr	Type
-----------	------	-----	------	-------	-----	------

Fa0/21	Altn BLK 19	128.21	P2p
Fa0/22	Root FWD 19	128.22	P2p

TASK:

- To verify the STP convergence process shutdown the SW1 f0/20 port and verify with Show spanning-tree

```
Sw1(config)#int f0/20
Sw1(config-if)#shutdown
```

Once f0/20 interface of SW1 or SW2 goes down, the alternate port f0/21 (SW3) comes to forwarding after delay of 50 sec

- o BLK 20 sec
- o LSN 15 sec
- o LRN 15 sec

```
Sw1(config)#int f0/20
Sw1(config-if)#shutdown
```

SW3#sh spanning-tree

```
VLAN0001
Spanning tree enabled protocol ieee
Root ID    Priority    32769
Address    0007.ECCD.AC82
Cost       19
Port       22(FastEthernet0/22)
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID  Priority    32769 (priority 32768 sys-id-ext 1)
Address    00D0.971E.4EAE
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 20
```

Interface	Role	Sts Cost	Prio.Nbr	Type
Fa0/21	Desg FWD	19	128.21	P2p
Fa0/22	Root FWD	19	128.22	P2p

TASK: Configure F0/20 port of SW1 back to normal state (no shutdown)

```
Sw1(config)# int f0/20
Sw1(config-if)# no shutdown
SW3#sh spanning-tree
VLAN0001
Spanning tree enabled protocol ieee
Root ID    Priority    32769
Address    0007.ECCD.AC82
```


Cost 19
Port 22(FastEthernet0/22)
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32769 (priority 32768 sys-id-ext 1)
Address 00D0.971E.4EAE
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 20

Interface	Role	Sts	Cost	Prio.	Nbr	Type
Fa0/21	Altn	BLK	19	128.21	P2p	
Fa0/22	Root	FWD	19	128.22	P2p	

Sw1#sh spanning-tree

VLAN0001

Spanning tree enabled protocol ieee

Root ID Priority 32769

Address 0007.ECCD.AC82

Cost 19

Port 20(FastEthernet0/20)

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32769 (priority 32768 sys-id-ext 1)

Address 00D0.580D.2EE0

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Aging Time 20

Interface	Role	Sts	Cost	Prio.	Nbr	Type
Fa0/20	Root	FWD	19	128.20	P2p	
Fa0/21	Desg	FWD	19	128.21	P2p	

- SW2 f0/21 goes back to BLK state
- SW1-F0/20 comes back to normal forward state after 30 sec delay (15 sec LSN , 15 sec LRN)

TASK:

- Configure SW1 to be the Root Bridge for Vlan 1 by changing the Priority value
- Verify the STP port states changes once we change the Root bridge

Configuring Spanning Tree

To change the STP priority value, use the following:

Switch (config)# spanning-tree vlan <vlan_no> < priority value>

Sw1(config)#spanning-tree vlan 1 priority ?

<0-61440> bridge priority in increments of 4096

Sw1(config)#spanning-tree vlan 1 priority 0

Sw1(config)#end

Sw1#sh spanning-tree

VLAN0001

Spanning tree enabled protocol ieee

Root ID Priority 1

Address 00D0.580D.2EE0

This bridge is the root

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 1 (priority 0 sys-id-ext 1)

Address 00D0.580D.2EE0

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Aging Time 20

Interface	Role	Sts	Cost	Prio.	Nbr	Type
-----------	------	-----	------	-------	-----	------

Fa0/20	Desg	FWD	19	128.20	P2p	
--------	------	-----	----	--------	-----	--

Fa0/21	Desg	FWD	19	128.21	P2p	
--------	------	-----	----	--------	-----	--

SW3#sh spanning-tree

VLAN0001

Spanning tree enabled protocol ieee

Root ID Priority 1

Address 00D0.580D.2EE0

Cost 19

Port 21(FastEthernet0/21)

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32769 (priority 32768 sys-id-ext 1)

Address 00D0.971E.4EAE

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Aging Time 20

Interface	Role	Sts	Cost	Prio.	Nbr	Type
-----------	------	-----	------	-------	-----	------

Fa0/21	Root	FWD	19	128.21	P2p	
--------	------	-----	----	--------	-----	--

Fa0/22	Altn	BLK	19	128.22	P2p	
--------	------	-----	----	--------	-----	--

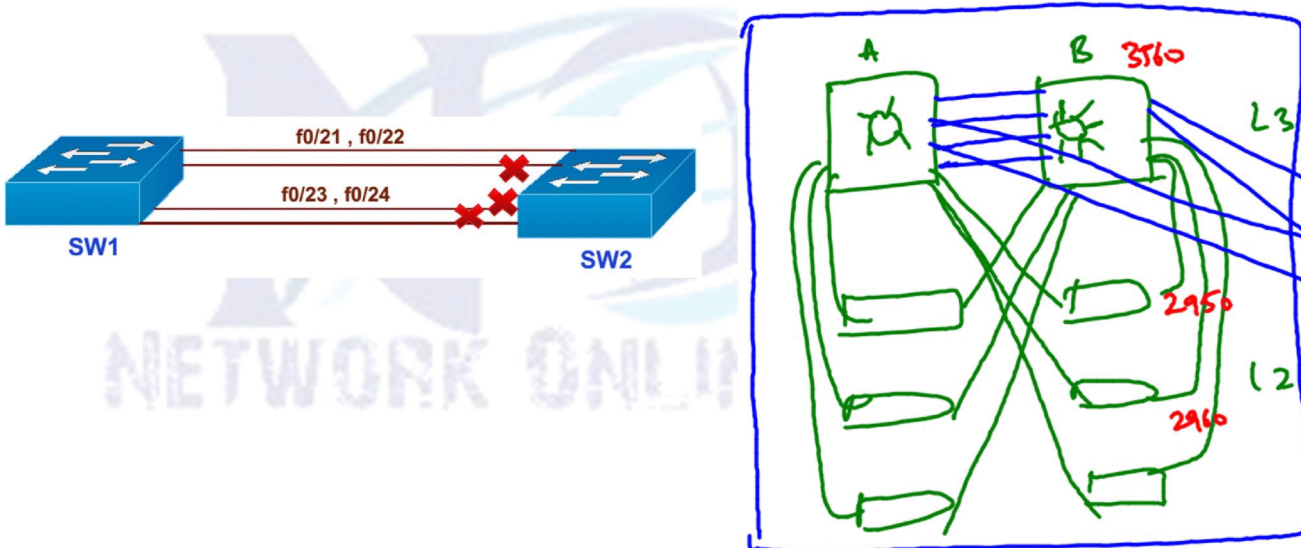
By default, STP is enabled for all active VLANs and on all ports of a switch. STP should remain enabled in a network to prevent bridging loops from forming.

- However, you might find that STP has been disabled in some way. If an entire instance of STP has been disabled, you can reenable it with the following global configuration command:
 - Switch(config)# spanning-tree vlan vlan-id
- If STP has been disabled for a specific VLAN on a specific port, you can reenable it with the following interface configuration command:
 - Switch (config-if)# spanning-tree vlan vlan-id



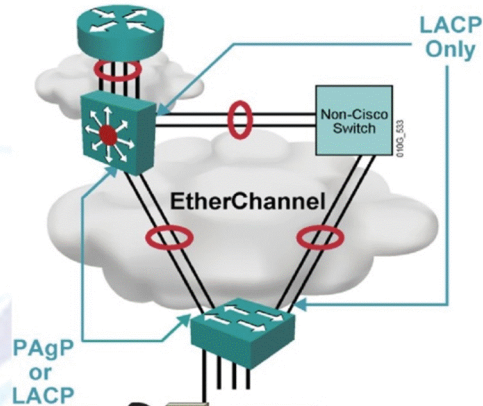
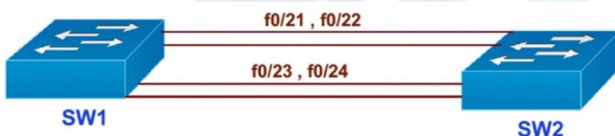
Ether channel

- ❖ Combining multiple Physical links in to one logical link.
- ❖ Increases bandwidth and provides redundancy.



Ether-channel - Configuration

1. Manual
2. Dynamic (using Negotiation protocols)
 - LACP , PAGP



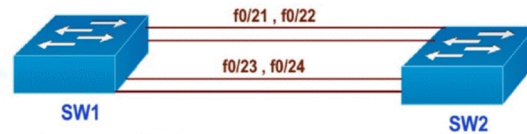
Switch(config)#**interface range f0/21 - 24**

Switch(config-if-range)#**channel-group 12 mode ?**

- active Enable LACP unconditionally
- auto Enable PAGP only if a PAGP device is detected
- desirable Enable PAGP unconditionally
- on Enable Etherchannel only
- passive Enable LACP only if a LACP device is detected

Ether-channel - Modes

Mode	Result
On	PAgP and LACP disabled (Disable Negotiation)
Desirable	Actively negotiate PAgP
Auto	Passively listen for PAgP
Active	Actively negotiate LACP
Passive	Passively listen for LACP



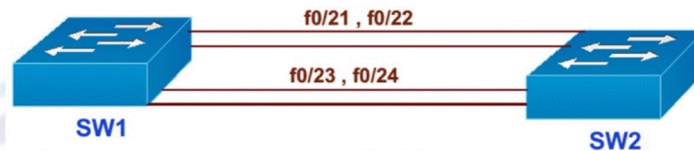
Switch(config)#**interface range f0/21 - 24**

Switch(config-if-range)#**channel-group 12 mode ?**

active Enable LACP unconditionally
auto Enable PAgP only if a PAgP device is detected
desirable Enable PAgP unconditionally
on Enable Etherchannel only
passive Enable LACP only if a LACP device is detected

Successful combination of ether-channel would be:

- On – On
- Desirable – Desirable
- Desirable – Auto
- Active – Active
- Active – Passive



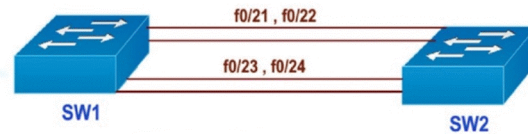
Switch(config)#**interface range f0/21 - 24**

Switch(config-if-range)#**channel-group 12 mode ?**

active Enable LACP unconditionally
auto Enable PAgP only if a PAgP device is detected
desirable Enable PAgP unconditionally
on Enable Etherchannel only
passive Enable LACP only if a LACP device is detected

Ether-channel - Configuration

```
SW-1(config)# interface range f0/21 - 24
SW-1(config-if-range)# channel-group 12 mode desirable
SW-1(config-if-range)# exit
```



```
SW-2(config)# interface range f0/21 - 24
SW-2(config-if-range)# channel-group 12 mode Auto
SW-2(config-if-range)# exit
```

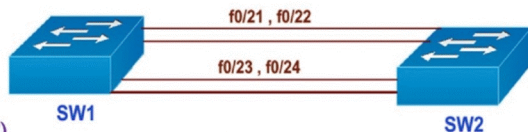
SW-1#show ip interface brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/24	unassigned	YES	unset	up	up
GigabitEthernet0/1	unassigned	YES	unset	down	down
GigabitEthernet0/2	unassigned	YES	unset	down	down
Vlan1	unassigned	YES	unset	administratively down	down
Port-channel 12	unassigned	YES	unset	up	up

SW-1#sh etherchannel summary

Number of channel-groups in use: 1
Number of aggregators: 1
Group Port-channel Protocol Ports

12	Po12(SU)	PAgP	Fa0/21(P)	Fa0/22(P)	Fa0/23(P)	Fa0/24(P)
----	----------	------	-----------	-----------	-----------	-----------



SW-1#show spanning-tree

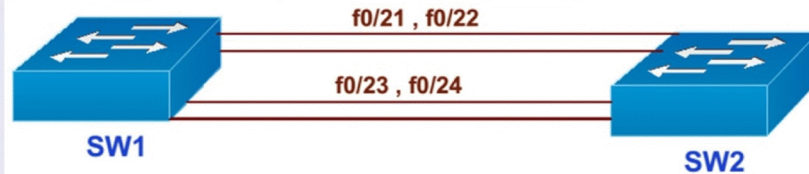
VLAN0001
Spanning tree enabled protocol ieee
Root ID Priority 32769
Address 00D0.FF28.367B
This bridge is the root
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32769 (priority 32768 sys-id-ext 1)
Address 00D0.FF28.367B
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 20

Interface	Role	Sts Cost	Prio.Nbr	Type
Po12	Desg	FWD 7	128.27	Shr

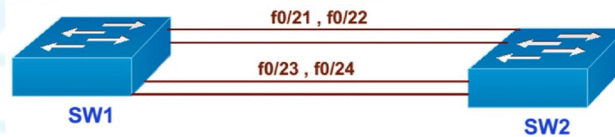
Etherchannel

- ❖ Up to 8 links can be used to combine in to one logical link.
- ❖ Etherchannel can be configured as layer 2 or layer 3.
- ❖ EtherChannel load balances traffic over all the links in the bundle.
- ❖ Port-channel is the logical instance of the physical interfaces.



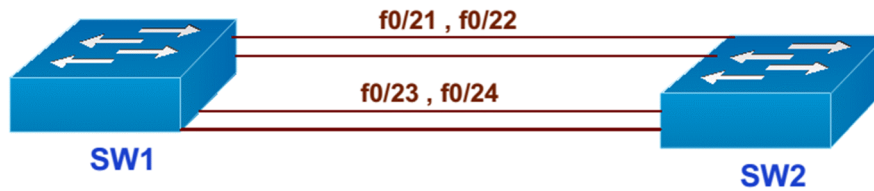
Some guidelines for EtherChannels

- ❖ All ports must be the same speed and duplex.
- ❖ All ports in the bundle should be enabled.
- ❖ all bundle ports in the same VLAN, or make them all trunks.
- ❖ If they are trunks, they must all carry the same VLANs and use the same trunking mode.



- ❖ Interfaces in the channel do not have to be physically next to each other or on the same module.
- ❖ Assign an IP address to the logical Port Channel interface, not the physical ones, if using a Layer 3 EtherChannel.
- ❖ The configuration you apply to the Port Channel interface affects the entire EtherChannel.
- ❖ The configuration you apply to a physical interface affects only that interface.

LAB : Configuring Ether-Channel Using Pagp Protocol Negotiation



TASK

- Configure the Four links (f0/20 – 23) should appear as one logical link
- Ports should negotiate using Cisco Proprietary method.

SW1

```
SW1(config)#int range f0/20 - 23
SW1(config-if-range)#channel-protocol pagp
SW1(config-if-range)#channel-group 10 ?
    mode Etherchannel Mode of the interface
SW1(config-if-range)#channel-group 10 mode ?
    active Enable LACP unconditionally
    auto Enable PAGP only if a PAGP device is detected
    desirable Enable PAGP unconditionally
    on Enable Etherchannel only
    passive Enable LACP only if a LACP device is detected
SW1(config-if-range)#channel-group 10 mode desirable
```

SW2

```
SW2(config)#int range f0/20 - 23
SW2(config-if-range)# channel-protocol pagp

SW2(config-if-range)# channel-group 10 mode ?
    active Enable LACP unconditionally
    auto Enable PAGP only if a PAGP device is detected
    desirable Enable PAGP unconditionally
    on Enable Etherchannel only
    passive Enable LACP only if a LACP device is detected
SW2(config-if-range)# channel-group 10 mode auto
SW2(config-if-range)#exit
```

SW2#sh etherchannel summary

```
Flags: D - down      P - in port-channel
       I - stand-alone s - suspended
       H - Hot-standby (LACP only)
       R - Layer3     S - Layer2
       U - in use     f - failed to allocate aggregator
       u - unsuitable for bundling
```


Port 27(Port-channel 10)
 Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
 Bridge ID Priority 32769 (priority 32768 sys-id-ext 1)
 Address 0060.4750.87A7
 Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
 Aging Time 20

Interface	Role	Sts	Cost	Prio.Nbr	Type
-----------	------	-----	------	----------	------

Po10	Root	FWD	7	128.27	Shr
------	------	-----	---	--------	-----

TASK: Configure the Portchannel 10 interface as Trunk link.

```

SW1(config)# int port-channel 10
SW1(config-if)# switchport trunk encapsulation dot1q
SW1(config-if)# switchport mode trunk
SW1(config-if)# exit
  
```

```

SW2(config)# int port-channel 10
SW2(config-if)# switchport trunk encapsulation dot1q
SW2(config-if)# switchport mode trunk
SW2(config-if)# exit
  
```

SW2#sh interfaces trunk

Port	Mode	Encapsulation	Status	Native vlan
Fa0/20	on	802.1q	trunking	1
Fa0/21	on	802.1q	trunking	1
Fa0/22	on	802.1q	trunking	1
Fa0/23	on	802.1q	trunking	1
Po10	on	802.1q	trunking	1

Port Vlans allowed on trunk

Fa0/20	1-1005
Fa0/21	1-1005
Fa0/22	1-1005
Fa0/23	1-1005
Po10	1-1005

Port Vlans allowed and active in management domain

Fa0/20	1
Fa0/21	1
Fa0/22	1
Fa0/23	1
Po10	1

Port Vlans in spanning tree forwarding state and not pruned

Fa0/20	none
--------	------

Fa0/21 none
Fa0/22 none
Fa0/23 none
Po10 none

- Any changes applied on the port channel automatically effect on all the physical interfaces
- Port channel will work as long as at least one interface in the group is up and running

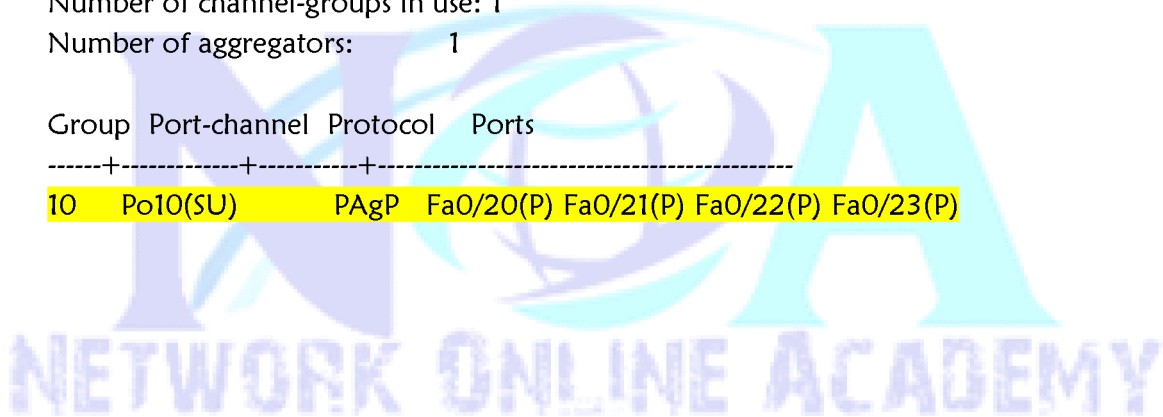
SW2#sh etherchannel summary

Flags: D - down P - in port-channel
I - stand-alone S - suspended
H - Hot-standby (LACP only)
R - Layer3 S - Layer2
U - in use f - failed to allocate aggregator
u - unsuitable for bundling
w - waiting to be aggregated
d - default port

Number of channel-groups in use: 1

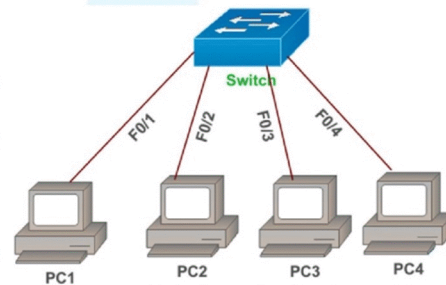
Number of aggregators: 1

Group	Port-channel	Protocol	Ports
10	Po10(SU)	PAgP	Fa0/20(P) Fa0/21(P) Fa0/22(P) Fa0/23(P)



Spanning tree Portfast

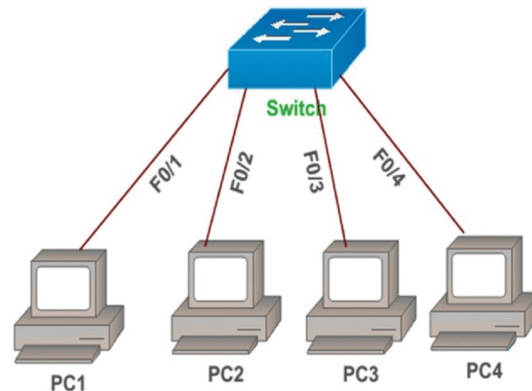
- ❖ helps speed up network convergence on access ports.
- ❖ Cisco-proprietary enhancement to Spanning Tree.
- ❖ Port Fast causes a port to enter the spanning-tree forwarding state immediately, bypassing the listening and learning states.



NOTE:

- ❖ PortFast should be used only when connecting a single end station to a switch port.
- ❖ If you enable PortFast on a port connected to another networking device, such as a switch, you can create network loops.

Portfast Configuration



Portfast on specific ports

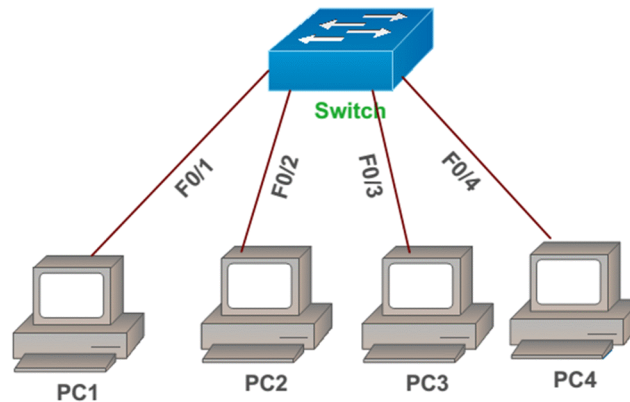
```
(config)# interface range f0/1 - 10
(config-if) spanning-tree portfast
```

OR

Portfast on all access ports globally using one command

```
(config)#spanning-tree portfast default
```


LAB: STP PORT FAST:



TASK:

- Connect Four PC in the LAN as per the Diagram.
- Shutdown the ports on Switch & reconfigure No shutdown and observe the ports going through LSN & LRN stages of STP process before they come to FWD...

```
Switch(config)#int range f0/1 - 4
Switch(config-if-range)# shutdown
Switch(config-if-range)# no shutdown
```

```
Switch#sh spanning-tree
```

```
VLAN0001
```

```
Spanning tree enabled protocol ieee
```

```
Root ID    Priority    32769
```

```
Address    0001.6336.1BA3
```

```
This bridge is the root
```

```
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
```

```
Bridge ID  Priority    32769 (priority 32768 sys-id-ext 1)
```

```
Address    0001.6336.1BA3
```

```
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
```

```
Aging Time 20
```

```
Interface    Role Sts Cost    Prio.Nbr Type
```

```
-----
Fa0/1        Desg LSN 19      128.1   P2p
Fa0/2        Desg LSN 19      128.2   P2p
Fa0/4        Desg LSN 19      128.4   P2p
Fa0/3        Desg LSN 19      128.3   P2p
```

```
Switch#sh spanning-tree
```

```
VLAN0001
```

```
Spanning tree enabled protocol ieee
```

```
Root ID    Priority    32769
```

Address 0001.6336.1BA3
This bridge is the root
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32769 (priority 32768 sys-id-ext 1)
Address 0001.6336.1BA3
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 20

Interface	Role	Sts	Cost	Prio.Nbr	Type
Fa0/1	Desg	LRN	19	128.1	P2p
Fa0/2	Desg	LRN	19	128.2	P2p
Fa0/4	Desg	LRN	19	128.4	P2p
Fa0/3	Desg	LRN	19	128.3	P2p

Switch#sh spanning-tree

VLAN0001
Spanning tree enabled protocol ieee
Root ID Priority 32769
Address 0001.6336.1BA3
This bridge is the root
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32769 (priority 32768 sys-id-ext 1)
Address 0001.6336.1BA3
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 20

Interface	Role	Sts	Cost	Prio.Nbr	Type
Fa0/1	Desg	FWD	19	128.1	P2p
Fa0/2	Desg	FWD	19	128.2	P2p
Fa0/4	Desg	FWD	19	128.4	P2p
Fa0/3	Desg	FWD	19	128.3	P2p

- All the ports connecting to end devices go through listening and Learning states by default before they comes to Forwarding State
- This is the default STP Loop prevention mechanism on switches
- Here we want these access ports to bypass the LSN, LRN stages and transition to FWD immediately
- To do this we configure portfast on these ports (used only on access ports)

Switch(config)#int range f0/1 - 4
Switch(config-if-range)#spanning-tree portfast

%Warning: portfast should only be enabled on ports connected to a single host. Connecting hubs, concentrators, switches, bridges, etc... to this interface when portfast is enabled, can cause temporary bridging loops.
Use with CAUTION

%Portfast will be configured in 4 interfaces due to the range command but will only have effect when the interfaces are in a non-trunking mode.

Switch(config-if-range)#end

TO verify:

```
Switch(config)#interface range f0/1 - 4
Switch(config-if-range)#shutdown
Switch(config-if-range)#no shutdown
```

Switch#sh spanning-tree

VLAN0001

Spanning tree enabled protocol ieee

Root ID Priority 32769

Address 0001.6336.1BA3

This bridge is the root

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32769 (priority 32768 sys-id-ext 1)

Address 0001.6336.1BA3

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

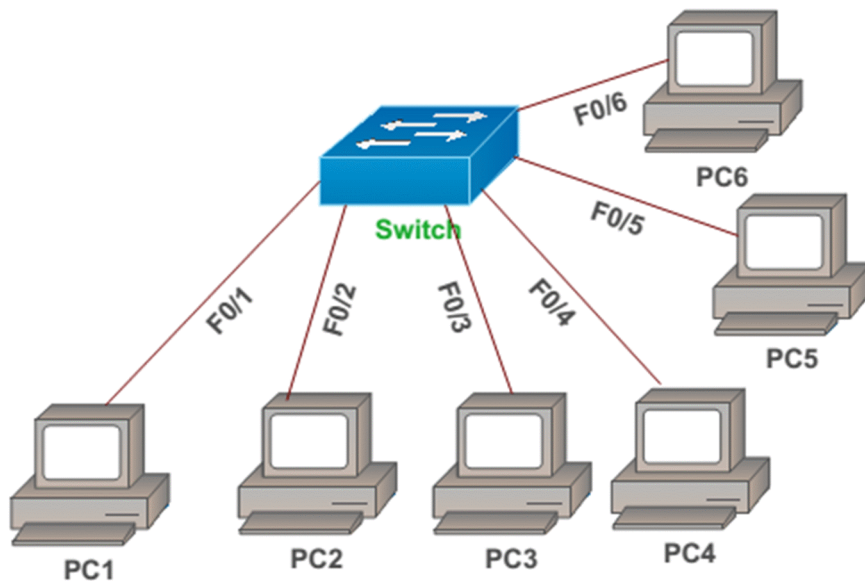
Aging Time 20

Interface	Role	Sts	Cost	Prio.Nbr	Type
Fa0/1	Desg	FWD	19	128.1	P2p
Fa0/2	Desg	FWD	19	128.2	P2p
Fa0/4	Desg	FWD	19	128.4	P2p
Fa0/3	Desg	FWD	19	128.3	P2p

Once port fast configured on the interfaces all the ports transitions to Forwarding immediately without LSN, LRN states

TASK:

- Configure Switch to ensure that all future access ports should bypass LSN, LRN states using single command.



```
Switch(config)#spanning-tree portfast default
Switch(config)#end
```

To Verify Connect some end devices on port F0/5 – 6 to verify

```
Switch#sh spanning-tree
```

```
VLAN0001
```

```
Spanning tree enabled protocol ieee
```

```
Root ID Priority 32769
```

```
Address 0001.6336.1BA3
```

```
This bridge is the root
```

```
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
```

```
Bridge ID Priority 32769 (priority 32768 sys-id-ext 1)
```

```
Address 0001.6336.1BA3
```

```
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
```

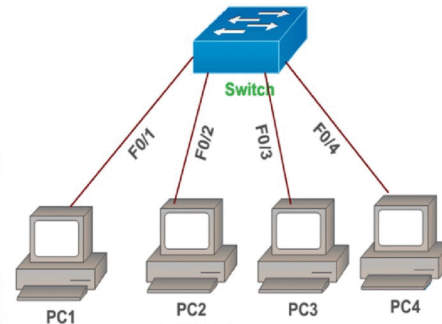
```
Aging Time 20
```

Interface	Role	Sts Cost	Prio.Nbr	Type
Fa0/1	Desg FWD	19	128.1	P2p
Fa0/6	Desg FWD	19	128.6	P2p
Fa0/5	Desg FWD	19	128.5	P2p
Fa0/2	Desg FWD	19	128.2	P2p
Fa0/4	Desg FWD	19	128.4	P2p
Fa0/3	Desg FWD	19	128.3	P2p

BPDU Guard

- ❖ BPDU Guard prevents loops if another switch is attached to a Portfast port.
- ❖ Puts port into an error-disabled state (basically, shut down) if a BPDU is received on the interface.

```
(config)# interface f0/1
(config-if)# spanning-tree portfast
(config-if)# spanning-tree bpduguard enable
```



BPDUGuard on all access ports globally using one command

OR

```
(config)# spanning-tree portfast bpduguard default
```

BPDU Guard verification

```
(config)# interface f0/2
(config-if)# spanning-tree portfast
(config-if)# spanning-tree bpduguard enable
```



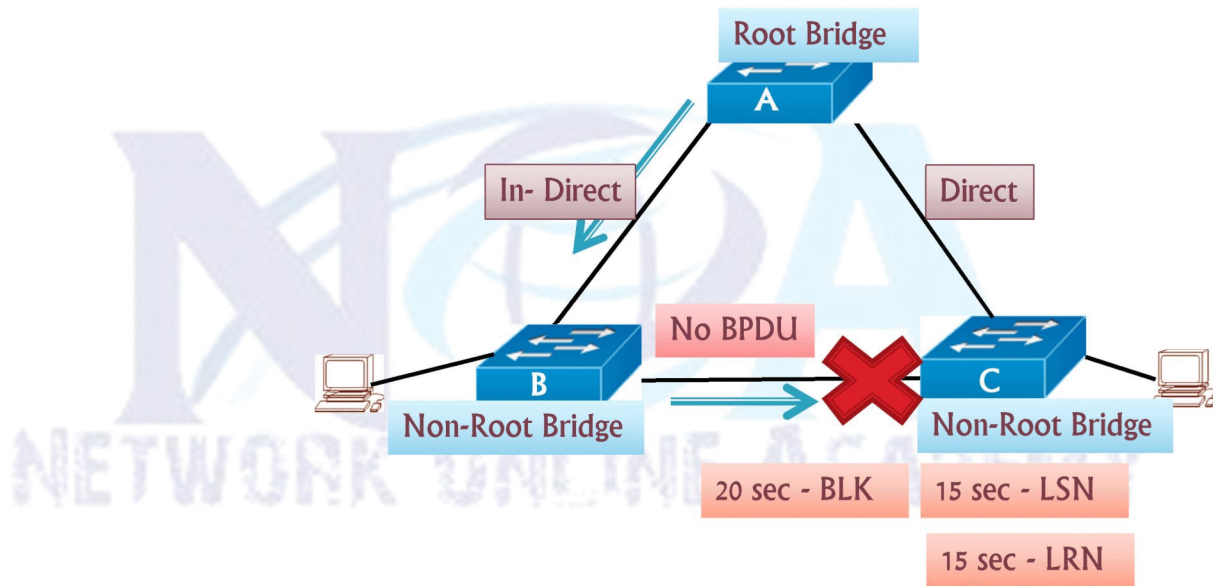
```
%SPANTREE-2-BLOCK_BPDUGUARD: Received BPDU on port FastEthernet0/2 with BPDU Guard enabled. Disabling port.
%PM-4-ERR_DISABLE: bpduguard error detected on Fa0/2, putting Fa0/2 in err-disable state
```

```
SW1#show interface status err-disabled
```

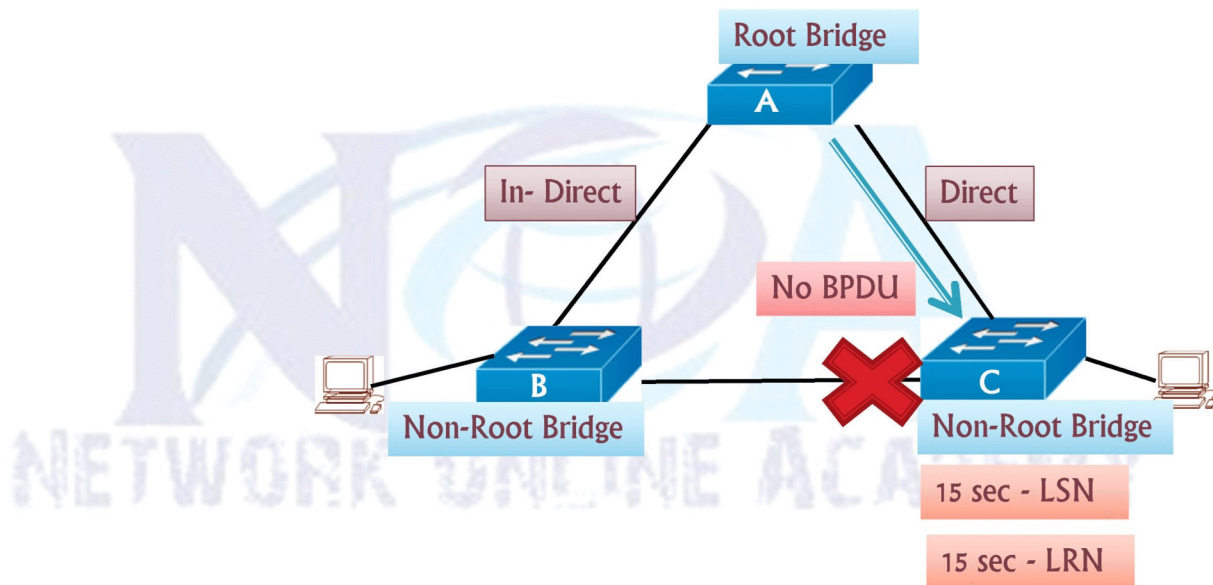
Port Name	Status	Reason Err-disabled	Vlans
Fa0/2	err-disabled	bpduguard	

- The port is err-disabled has to be manually re-enabled via shut/no shut.

STP Convergence – Indirect- link failure



STP Convergence - Direct- link failure



Spanning-tree Uplink-fast / Backbone-fast

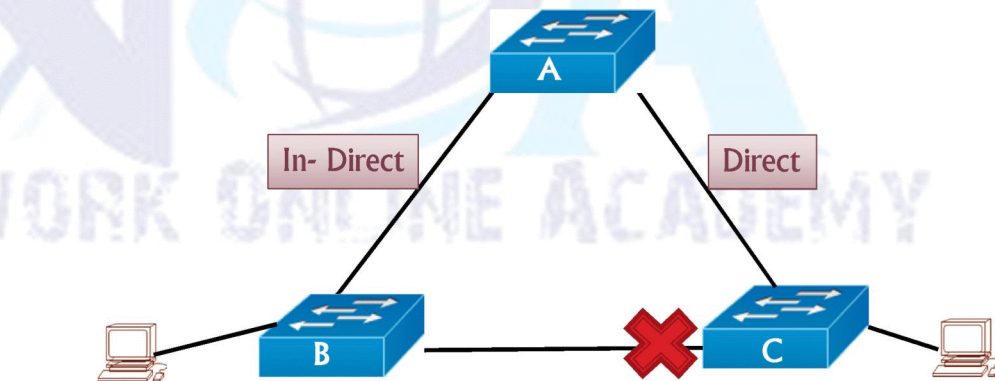
- ❖ Legacy / Cisco proprietary enhancement to speed up the convergence.

Uplink-fast

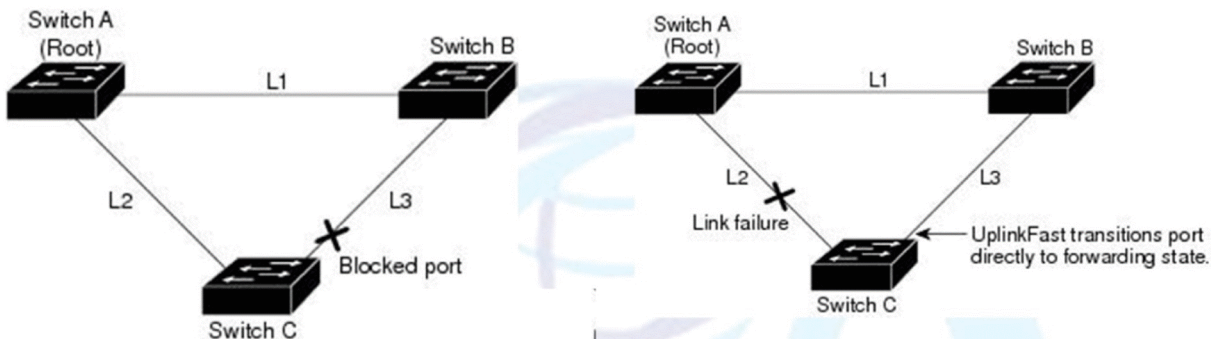
- ❖ BLK → FWD Immediately if direct-link fails (instead of 30sec)

Backbone-fast

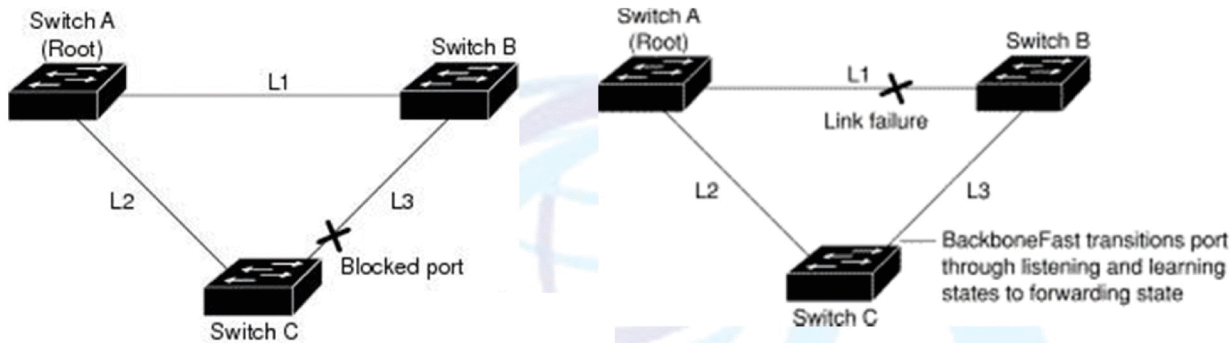
- ❖ BLK → FWD 30sec if direct-link fails (instead of 50 sec)



Spanning-tree uplink-fast



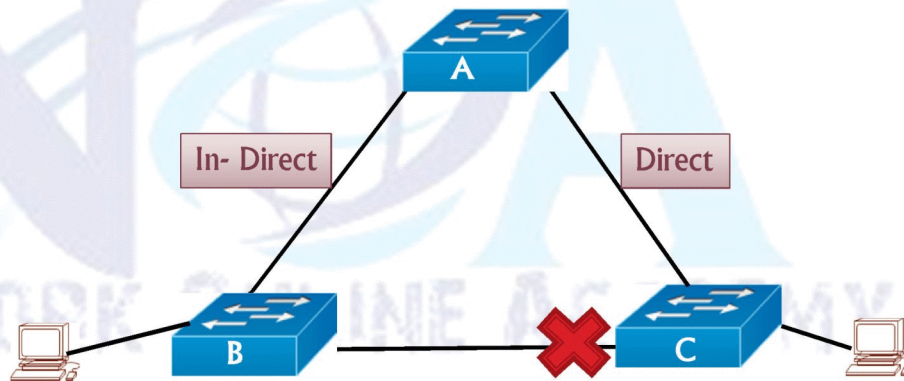
Spanning-tree Backbonefast



- ❖ Legacy / Cisco proprietary feature
- ❖ Backbone Fast can reduce the maximum convergence delay only from 50 to 30 seconds.

Rapid STP (RSTP) 802.1w

- ❖ 802.1w is a standards way of speeding STP convergence.
- ❖ Inbuilt features of portfast, uplinkfast, backbonefast, BPDUfilter
- ❖ Path Calculation remains same as STP.



RSTP Configuration

(config)#spanning-tree mode rapid-pvst

#show spanning-tree

VLAN0001

Spanning tree enabled protocol rstp

Root ID Priority 32769

Address 0001.C9A4.567D

Cost 19

Port 20(FastEthernet0/20)

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32769 (priority 32768 sys-id-ext 1)

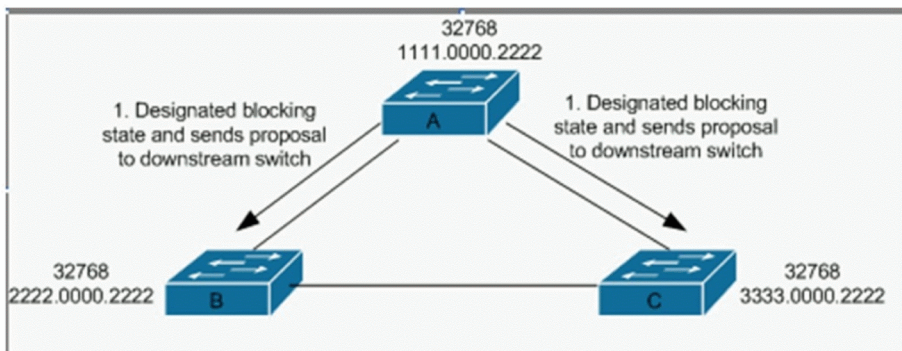
Address 000A.414A.42D8

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

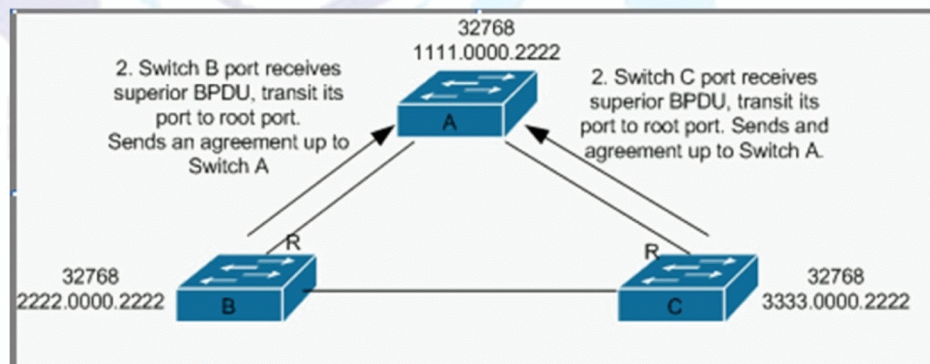
Aging Time 20

Interface	Role	Sts	Cost	Prio.Nbr	Type
Fa0/20	Root	FWD	19	128.20	P2p

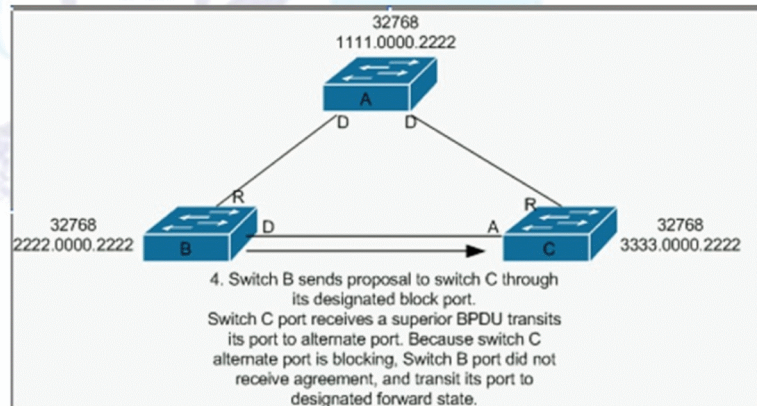
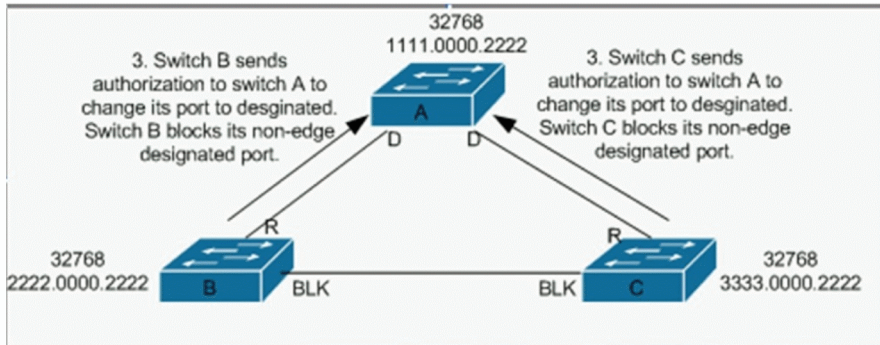
RSTP Synchronization



SWA assumes its port is designated and sends out a proposal.
SWB will agree to this proposal.



RSTP Synchronization

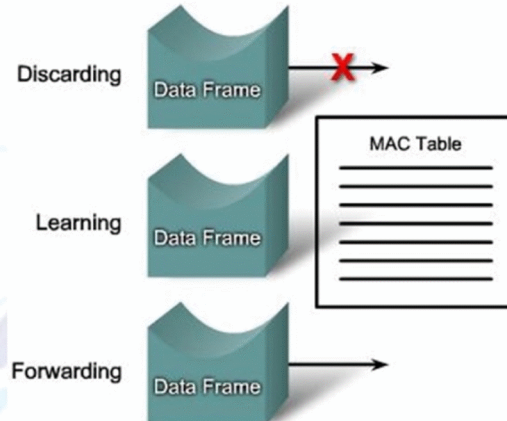


RSTP port States

Comparing 802.1d and 802.1w Port States

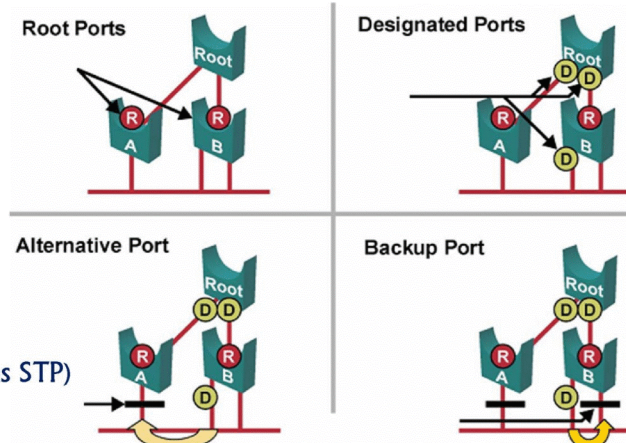
STP Port State Equivalent RSTP Port State

Disabled	Discarding
Blocking	Discarding
Listening	Discarding
Learning	Learning
Forwarding	Forwarding



- **Discarding** - Frames are dropped, no addresses are learned. (link down / blocking/during sync)
- **Learning** - Frames are dropped, but addresses are learned.
- **Forwarding** - Frames are forwarded

RSTP port roles

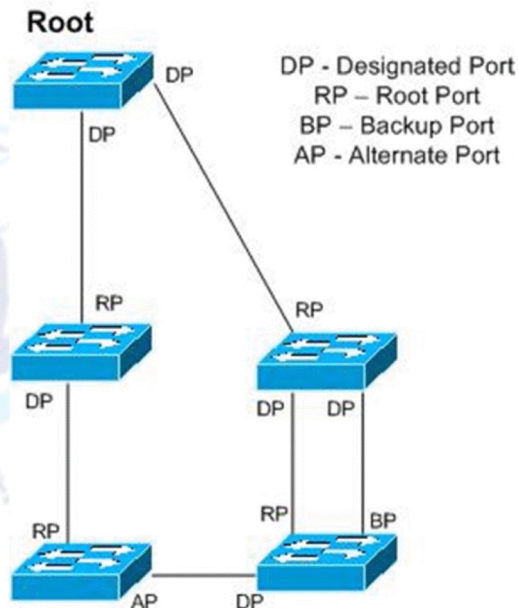


Root port:	The best path to the root (same as STP)
Designated port:	Same role as with STP
Alternate port:	A backup to the root port
Backup port:	A backup to the designated port
Disabled port:	Not used in the Spanning Tree
Edge port:	Connected only to an end user

RSTP port roles (Contd)

Alternate port:

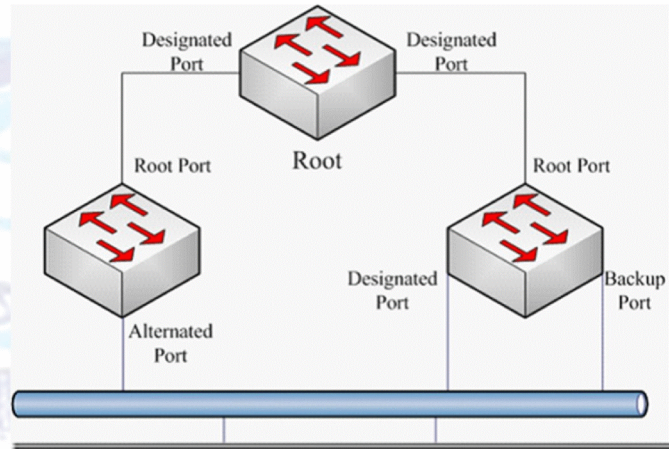
- ❖ A backup to the root port
- ❖ Less desirable path to the root
- ❖ Operates in discarding state.
- ❖ Same as uplinkfast (legacy)



RSTP port roles (Contd)

Backup port:

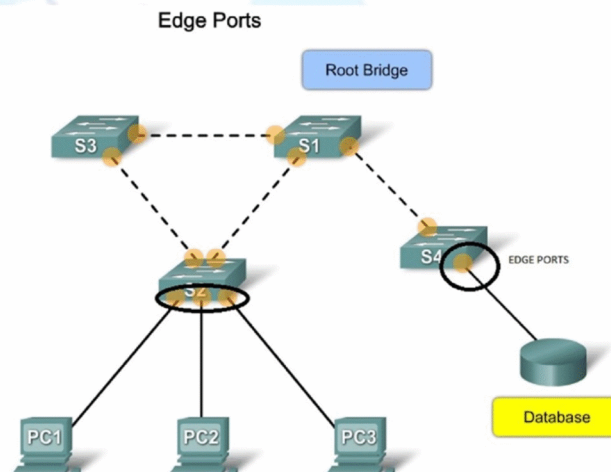
- ❖ The backup port applies only when a single switch has two links to the same segment (collision domain).
- ❖ To have two links to the same collision domain, the switch must be attached to a hub.
- ❖ A backup to the designated port
- ❖ Multiple links attached to the same network segment
- ❖ Activates if primary designated fails.



RSTP port roles (Contd)

Edge port:

- ❖ Equivalent to portfast in STP.
- ❖ Connected only to an end user .
- ❖ Maintain edge status as long as no BPDU received (with BPDU filter) .



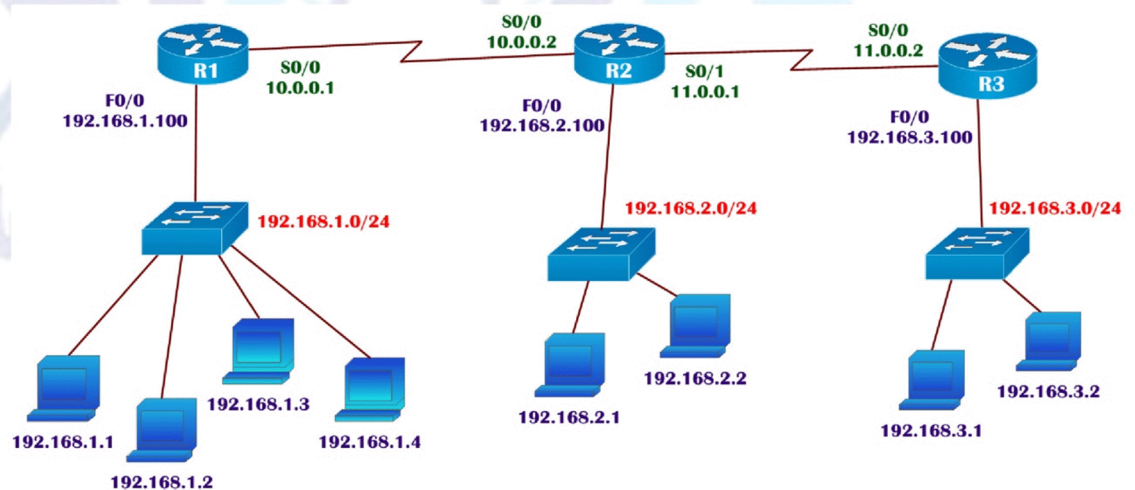
BPDUs Differences in RSTP

- ❖ In regular STP, BPDUs are originated by the root and relayed by each switch.
- ❖ In RSTP, each switch originates BPDUs, whether or not it receives a BPDU on its root port. PVST is done by Rapid PVST+ on Catalyst switches.
- ❖ Hello= 2 sec , Dead = 6 sec

ACCESS CONTROL LIST

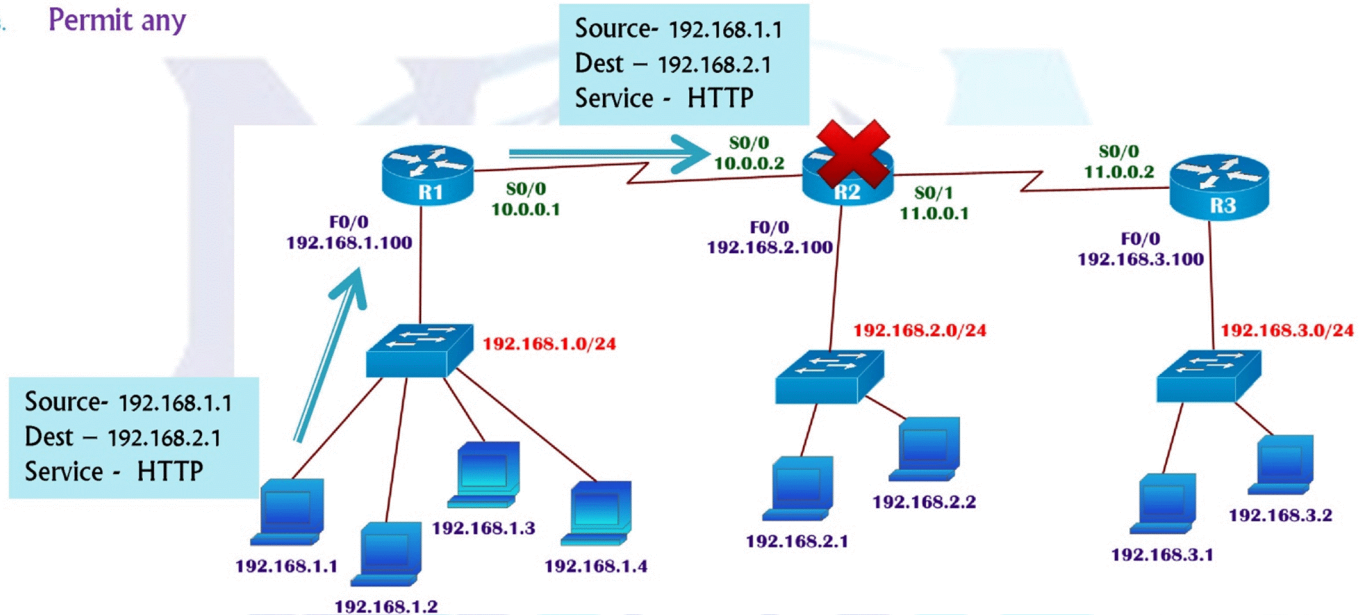
ACCESS CONTROL LIST (ACL)

- ▶ ACL is a set of rules which will allow or deny the specific traffic moving through the router
- ▶ controls the flow of traffic from one network to other via router



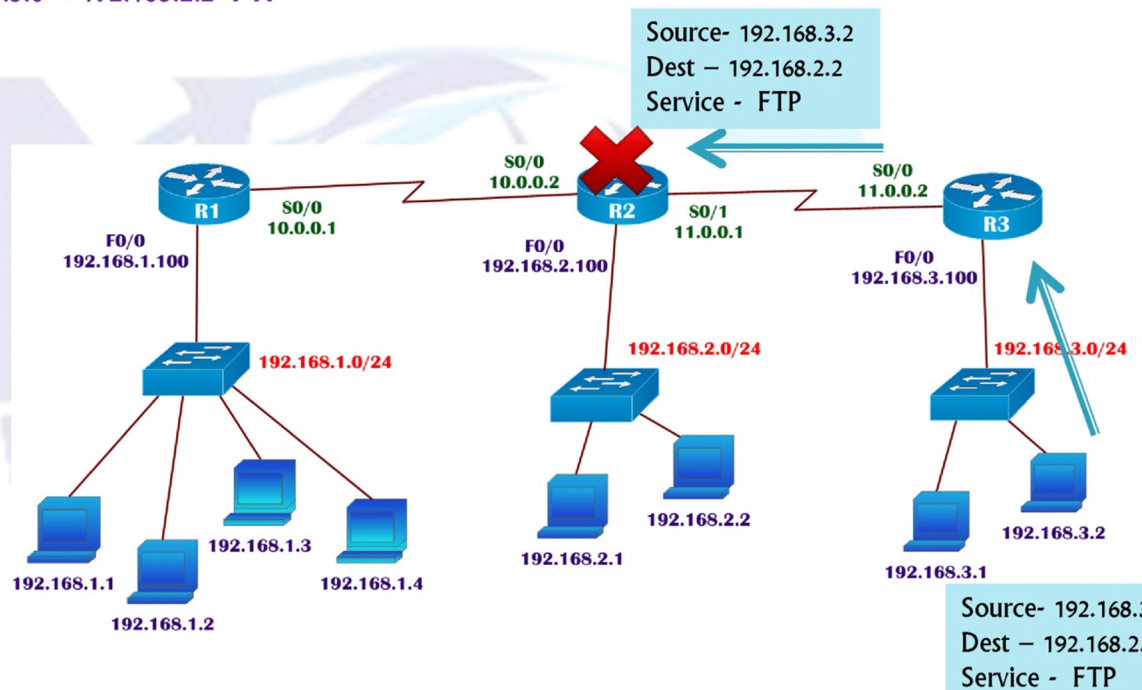
Set of Rules - ACL

1. Deny 192.168.1.0 = 192.168.2.1 HTTP
2. Deny 192.168.3.0 = 192.168.2.2 FTP
3. Permit any



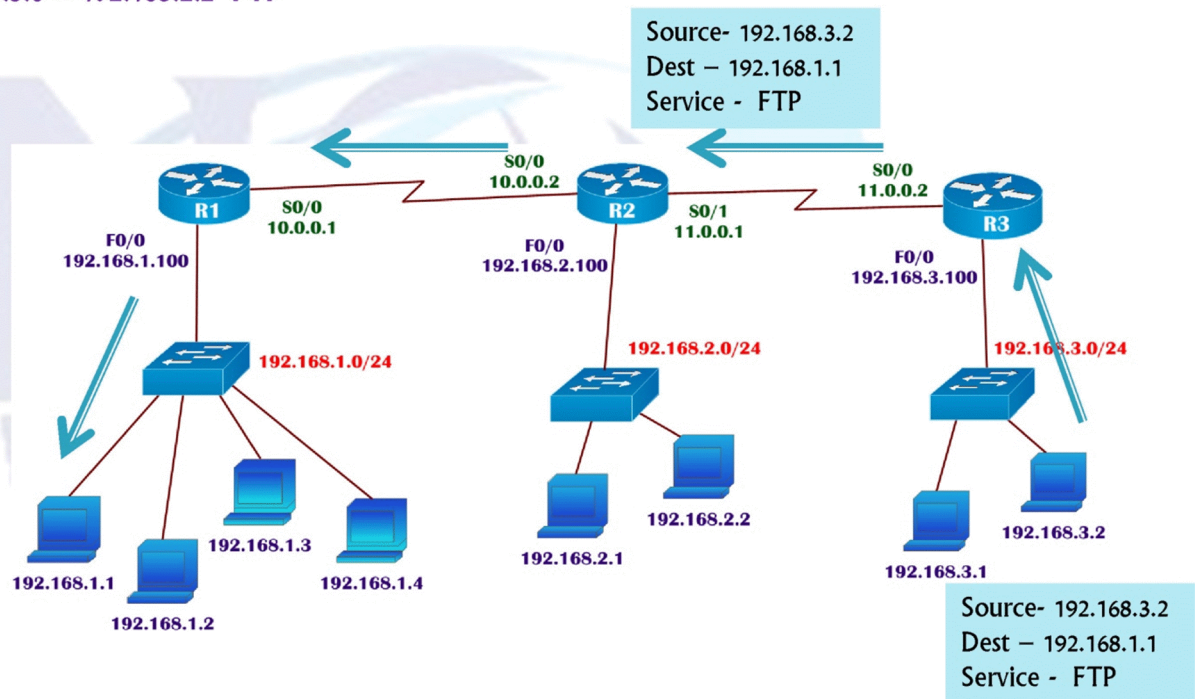
Set of Rules - ACL

1. Deny 192.168.1.0 = 192.168.2.1 HTTP
2. Deny 192.168.3.0 = 192.168.2.2 FTP
3. Permit any



Set of Rules - ACL

1. Deny 192.168.1.0 = 192.168.2.1 HTTP
2. Deny 192.168.3.0 = 192.168.2.2 FTP
3. Permit any



Types of Access-list

Numbered ACL - set of rules Identified by a number

1. Deny 192.168.1.0 = 192.168.2.1 HTTP
2. Deny 192.168.3.0 = 192.168.2.2 FTP
3. Permit any

ACL - 120

Named ACL - set of rules rules Identified by a name.

1. Deny 192.168.1.0 = 192.168.2.1 HTTP
2. Deny 192.168.3.0 = 192.168.2.2 FTP
3. Permit any

ACL - CCNA

Standard ACL

1. Can be named or numbered.
2. The access-list number range is 1 – 99 (or 1300 – 1699)
3. Can block a Network, Host and Subnet. (not selected services)
4. All services are blocked.
5. Filtering is done based on only source IP address

Extended ACL

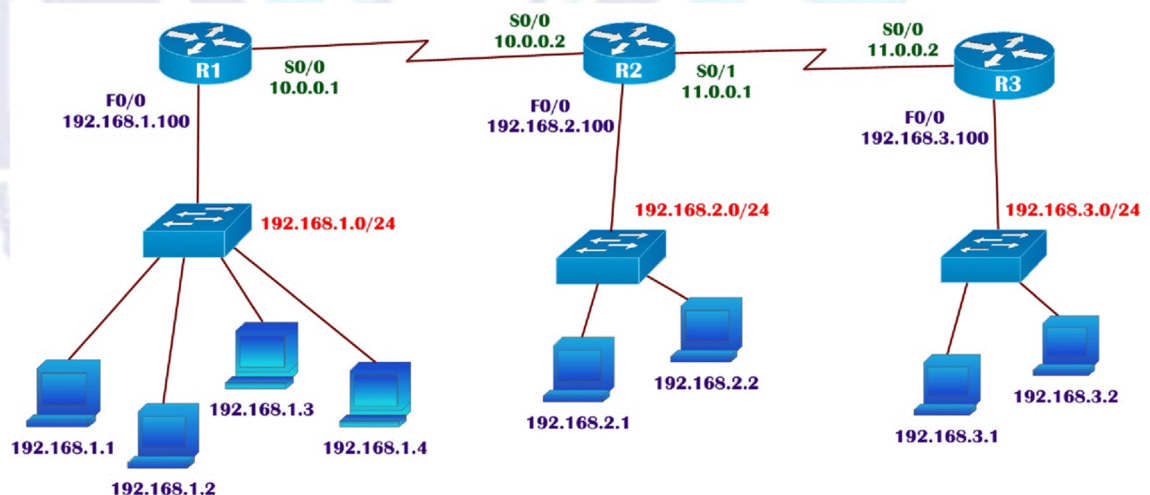
1. Can be named or numbered.
2. The access-list number range is 100 – 199 (or 2000-2699)
3. We can allow or deny a Network, Host, Subnet and Service
4. Selected services can be blocked.
5. Filtering is done based on source IP , destination IP , protocol, port no

Lab : Standard Access-list

TASK: Configure the Appropriate router as per the rules given

1. Deny the host 192.168.1.1 communicating with 192.168.2.0
2. Deny the host 192.168.1.2 communicating with 192.168.2.0
3. Deny the network 192.168.3.0 communicating with 192.168.2.0
4. Permit all the remaining traffic

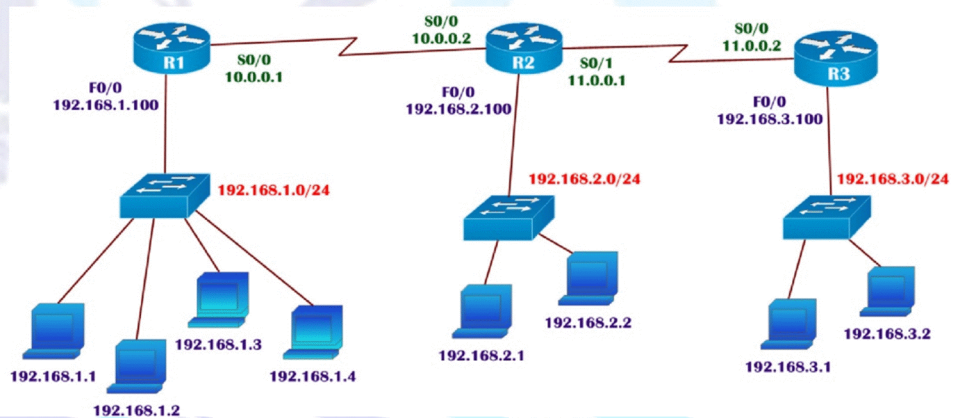
NOTE: the Above ACL rules should not affect the other communication



To write ACL Statement

- On which Router to implement ACL
- Identify Source & Destination
- In/out
- Ensure that the router you are implementing ACL must be the transit router . (R2)
- Think your router as destination (incoming as source).
- Standard ACL checks only the source address

1. Deny - 192.168.1.1 - 192.168.2.0
2. Deny - 192.168.1.2 - 192.168.2.0
3. Deny - 192.168.3.0 - 192.168.2.0
4. Permit any



Wild card mask

Tells the router which portion of the bits to match or ignore.

- 0 = must match
- 1 = ignore

Global Subnet Mask

- Subnet Mask

=====

Wildcard mask

=====

255. 255. 255. 255

255. 255. 255. 0

=====

0. 0. 0. 255

=====

255. 255. 255. 255

255. 255. 255. 240

=====

0. 0. 0. 15

=====

- Wild Card Mask for Network will be Inverse mask.(above method)

Wild card mask for single host

Default mask for one single host always = /32 = 255.255.255.255

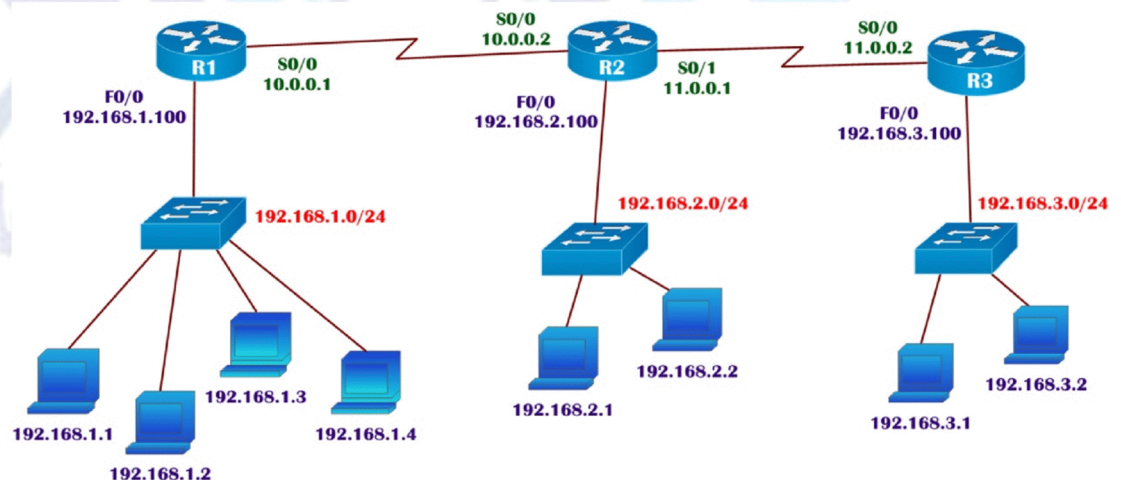
Global Subnet Mask	255. 255. 255. 255
- Subnet Mask	255. 255. 255. 255
=====	=====
Wildcard mask	0. 0. 0. 0
=====	=====

- Wild Card Mask for a Host will be always 0.0.0.0

Router(config)# access-list <acl no> <permit/deny> <source address> <source WCM>

```
R-2(config)# access-list 15 deny 192.168.1.1 0.0.0.0
R-2(config)# access-list 15 deny host 192.168.1.2
R-2(config)# access-list 15 deny 192.168.3.0 0.0.0.255
R-2(config)# access-list 15 permit any
```

	Source	Destination
1)	Deny - 192.168.1.1	192.168.2.0
2)	Deny - 192.168.1.2	192.168.2.0
3)	Deny - 192.168.3.0	192.168.2.0
4)	Permit any	

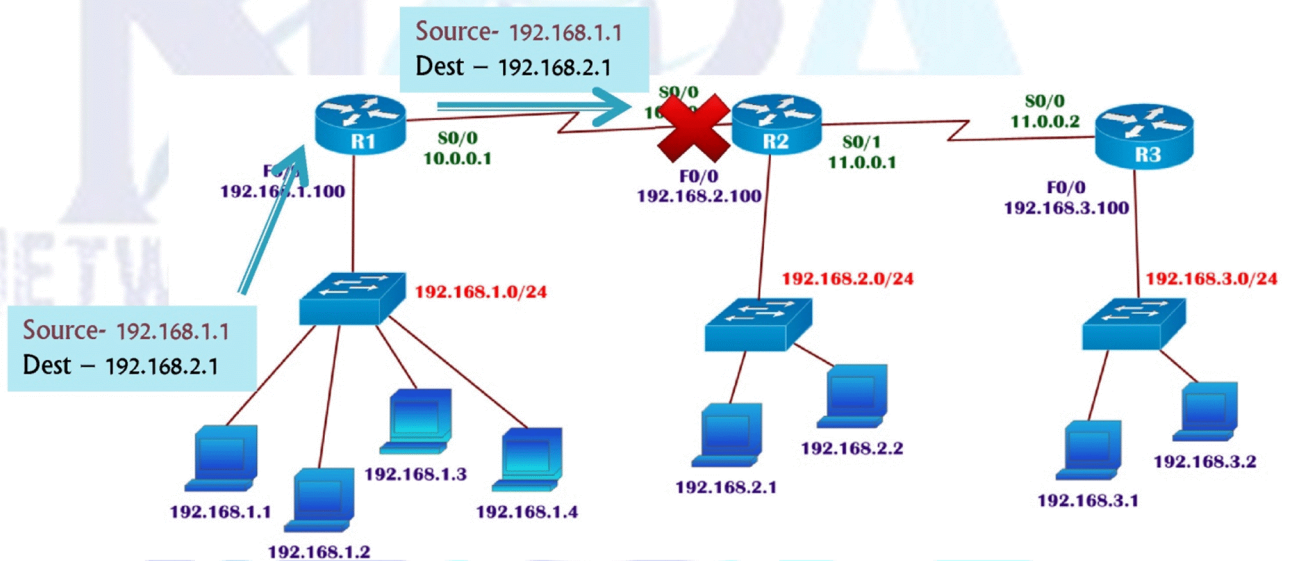


Deciding the right interface to implement ACL

R2 is configured with ACL has three interfaces –

- ▶ F0/0 , s0/0 , s0/1

	Source	Destination
1)	Deny - 192.168.1.1	192.168.2.0
2)	Deny - 192.168.1.2	192.168.2.0
3)	Deny - 192.168.3.0	192.168.2.0
4)	Permit	any

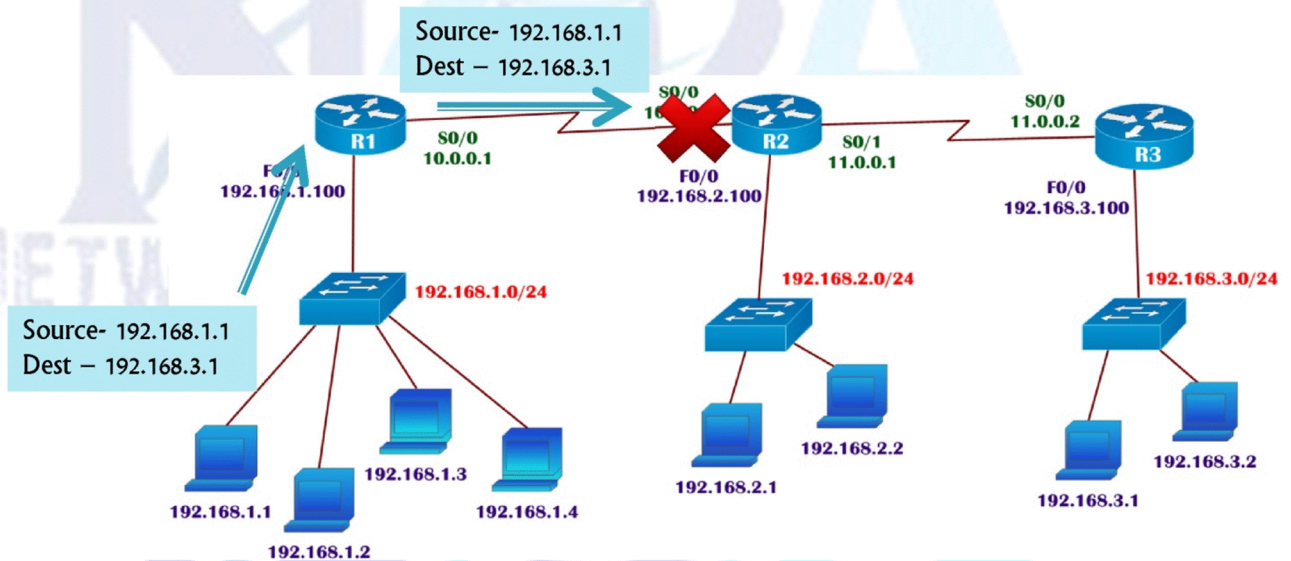


Deciding the right interface to implement ACL

R2 is configured with ACL has three interfaces –

- F0/0 , s0/0 , s0/1

	Source	Destination
1)	Deny - 192.168.1.1	192.168.2.0
2)	Deny - 192.168.1.2	192.168.2.0
3)	Deny - 192.168.3.0	192.168.2.0
4)	Permit	any



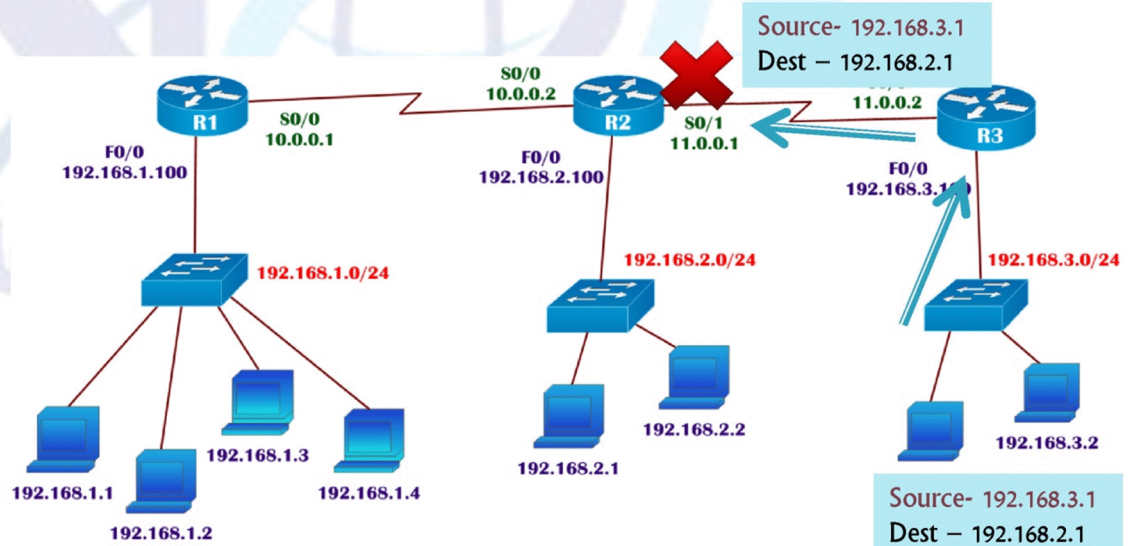
NETWORK ONLINE ACADEMY

Deciding the right interface to implement ACL

R2 is configured with ACL has three interfaces –

- F0/0 , s0/0 , s0/1

	Source	Destination
1)	Deny - 192.168.1.1 - 192.168.2.0	
2)	Deny - 192.168.1.2 - 192.168.2.0	
3)	Deny - 192.168.3.0 - 192.168.2.0	
4)	Permit any	

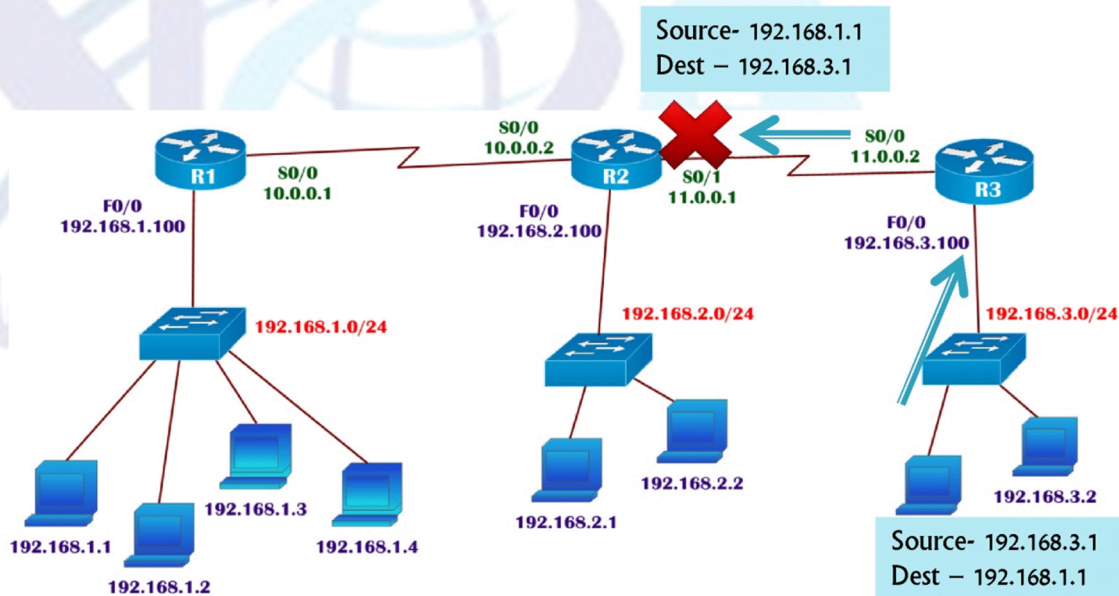


Deciding the right interface to implement ACL

R2 is configured with ACL has three interfaces –

- ▶ F0/0 , s0/0 , s0/1

	Source	Destination
1)	Deny - 192.168.1.1	192.168.2.0
2)	Deny - 192.168.1.2	192.168.2.0
3)	Deny - 192.168.3.0	192.168.2.0
4)	Permit any	

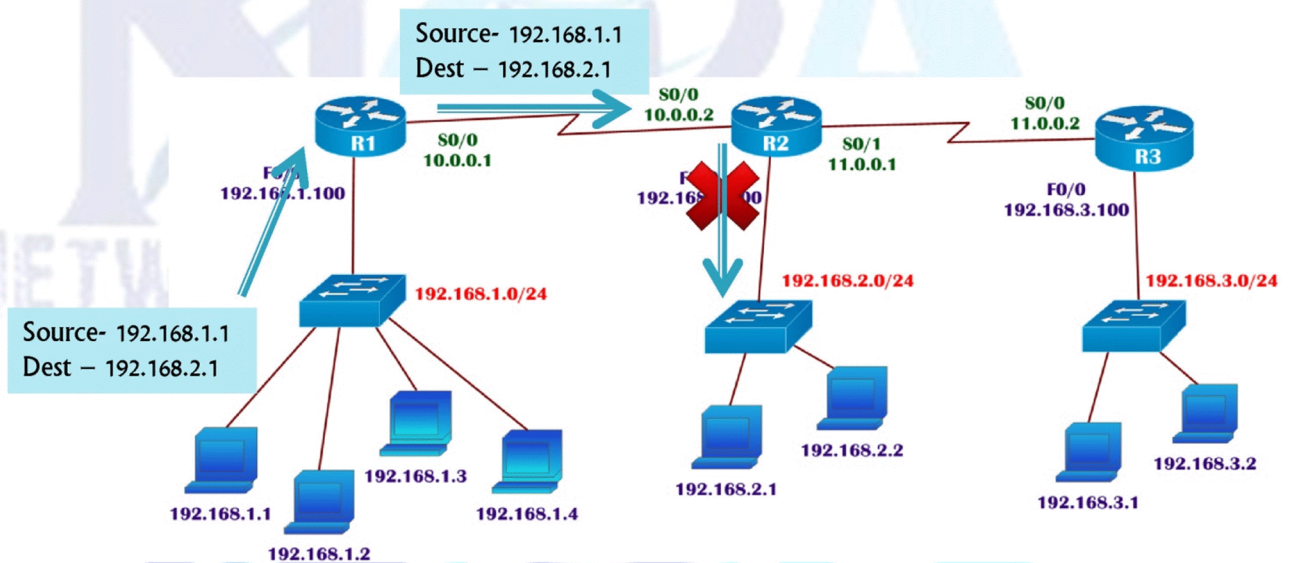


Deciding the right interface to implement ACL

R2 is configured with ACL has three interfaces –

- ▶ F0/0 , s0/0 , s0/1

	Source	Destination
1)	Deny - 192.168.1.1	192.168.2.0
2)	Deny - 192.168.1.2	192.168.2.0
3)	Deny - 192.168.3.0	192.168.2.0
4)	Permit any	

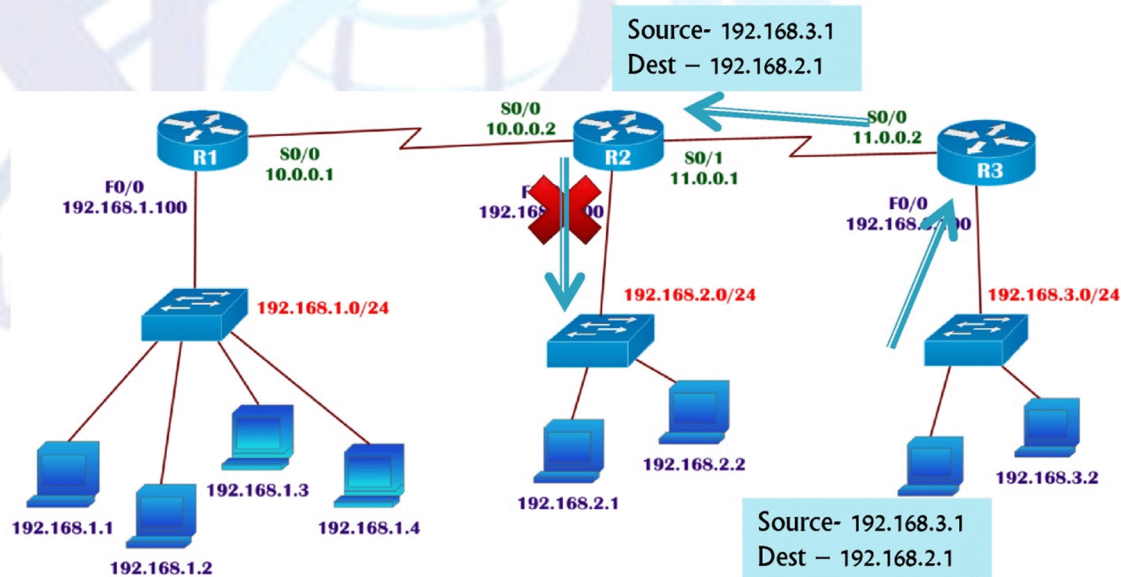


Deciding the right interface to implement ACL

R2 is configured with ACL has three interfaces –

- F0/0 , s0/0 , s0/1

	Source	Destination
1)	Deny - 192.168.1.1 - 192.168.2.0	
2)	Deny - 192.168.1.2 - 192.168.2.0	
3)	Deny - 192.168.3.0 - 192.168.2.0	
4)	Permit any	

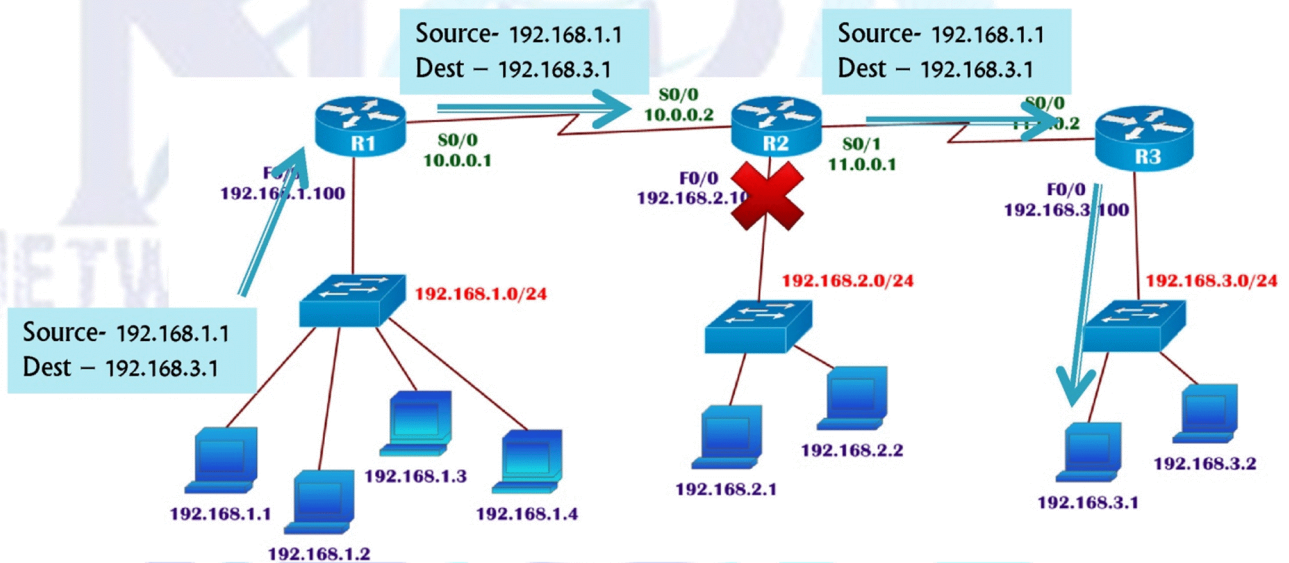


Deciding the right interface to implement ACL

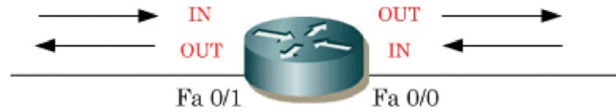
R2 is configured with ACL has three interfaces –

► , s0/0 , s0/1 , F0/0

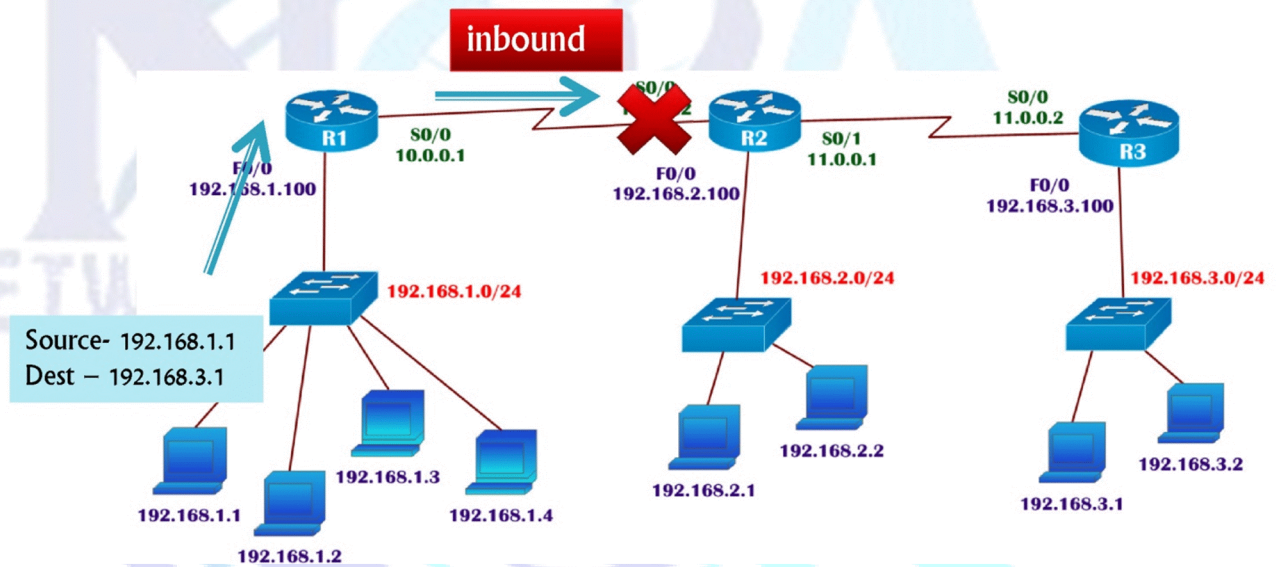
	Source	Destination
1)	Deny - 192.168.1.1	192.168.2.0
2)	Deny - 192.168.1.2	192.168.2.0
3)	Deny - 192.168.3.0	192.168.2.0
4)	Permit	any



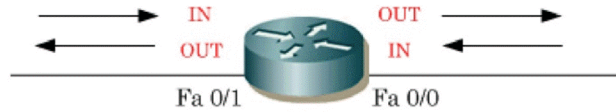
Understanding inbound / outbound



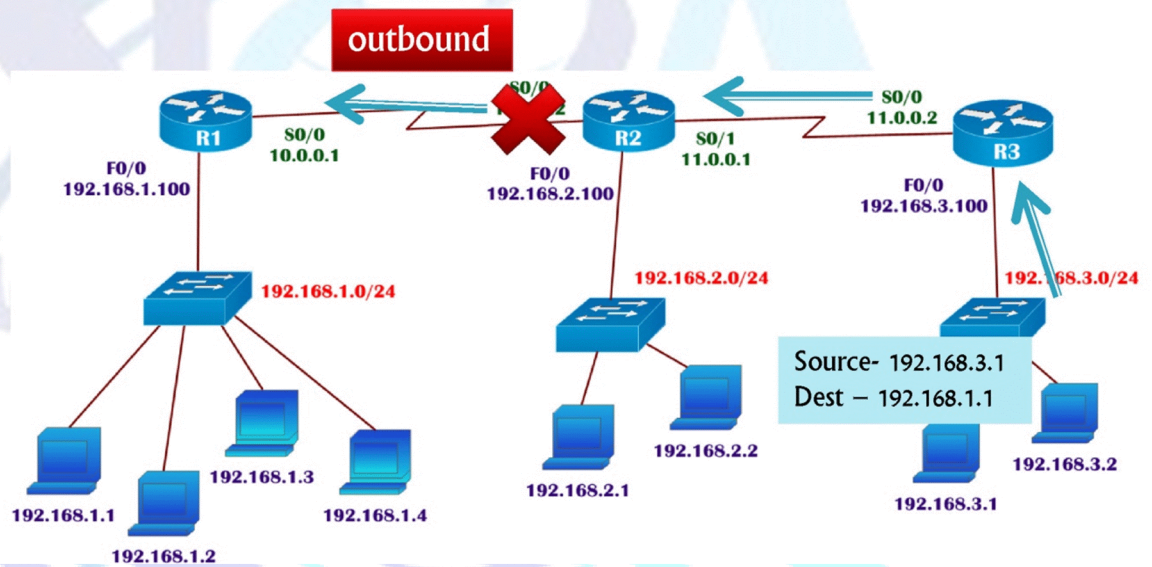
- ▶ Inbound - traffic coming towards the router interface
- ▶ Outbound - traffic leaving the router interface



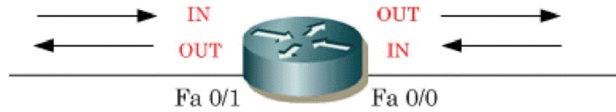
Understanding inbound / outbound



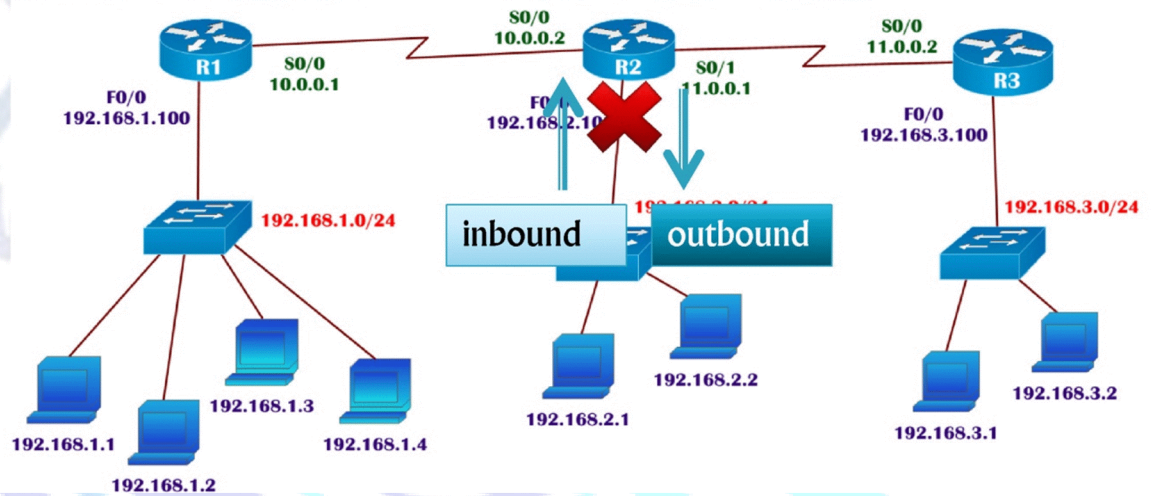
- ▶ Inbound - traffic coming towards the router interface
- ▶ Outbound - traffic leaving the router interface



Understanding inbound / outbound



- ▶ Inbound - traffic coming towards the router interface
- ▶ Outbound - traffic leaving the router interface



ACL Implementation

```
R-2(config)#interface fastEthernet 0/0
```

```
R-2(config-if)#ip access-group 15 out
```

```
R-2#sh access-lists
```

Standard IP access list 15

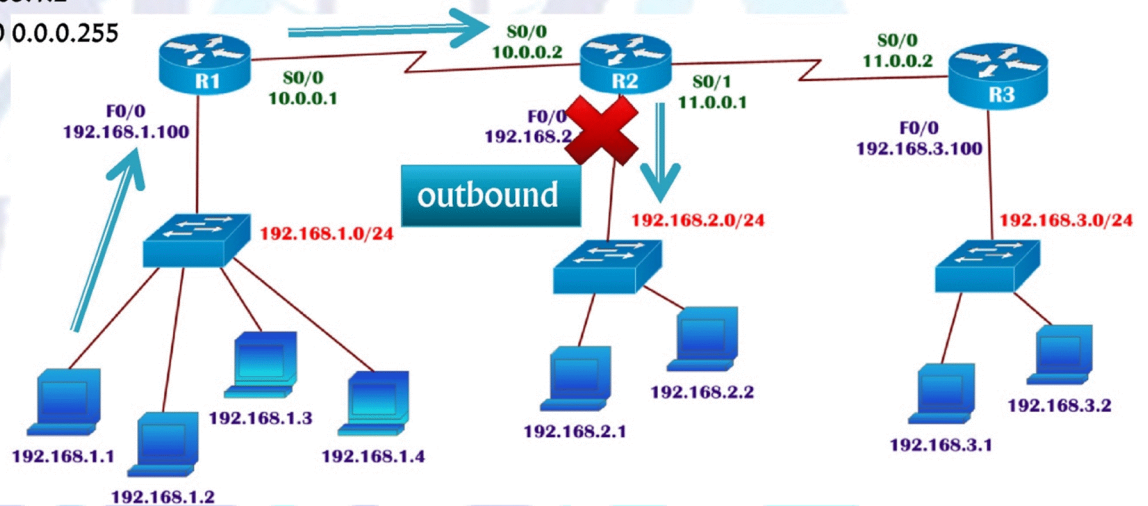
```
deny host 192.168.1.1
```

```
deny host 192.168.1.2
```

```
deny 192.168.3.0 0.0.0.255
```

```
permit any
```

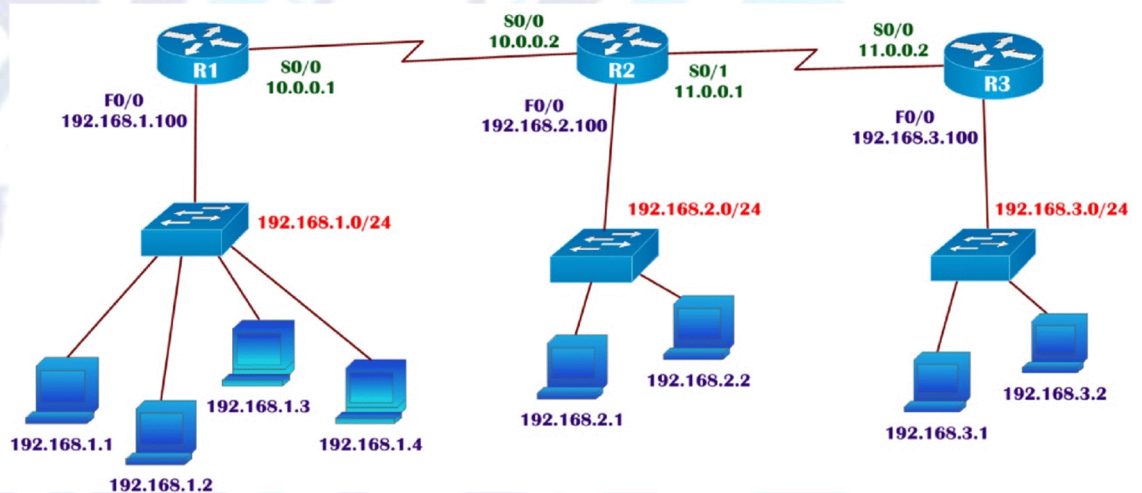
	Source	Destination
1)	Deny - 192.168.1.1	192.168.2.0
2)	Deny - 192.168.1.2	192.168.2.0
3)	Deny - 192.168.3.0	192.168.2.0
4)	Permit any	



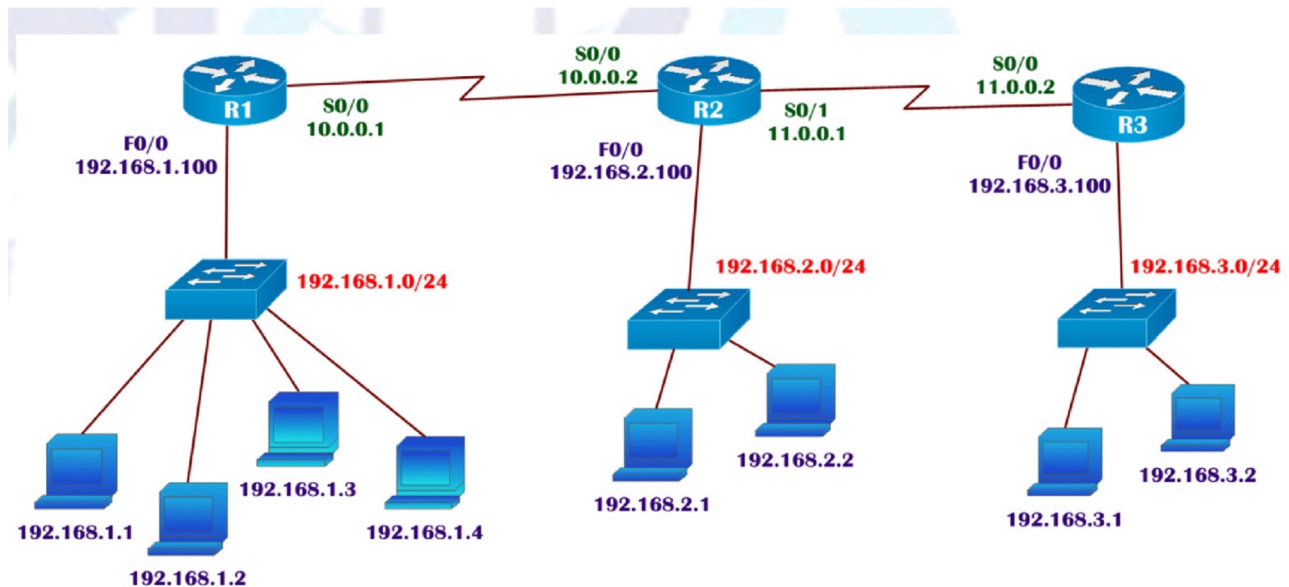
ACL Rules

- ▶ ACL works in sequential order.
- ▶ Deny to be given first (preferred)
- ▶ must have at least one permit statement.
- ▶ If no statement matches ACL will drop the traffic by default.
- ▶ Two ACL can be implemented on every interface (in/out).

	Source	Destination
1)	Deny - 192.168.1.1	- 192.168.2.0
2)	Deny - 192.168.1.2	- 192.168.2.0
3)	Deny - 192.168.3.0	- 192.168.2.0
4)	Permit	any



LAB – 1: STANDARD ACCESS-LIST



Pre-requirement for LAB (check previous labs)

- 1) Design the topology (connectivity)
- 2) Assign the IP address according to diagram
- 3) Make sure that interfaces used should be in UP state
- 4) Any dynamic routing Protocol or static routing
- 5) Verify Routing table and reachability between the LAN's (using PING and TRACE commands)

TASK: Configure the Appropriate router as per the rules given

- Deny the host 192.168.1.1 communicating with 192.168.2.0
- Deny the host 192.168.1.2 communicating with 192.168.2.0
- Deny the network 192.168.3.0 communicating with 192.168.2.0
- Permit all the remaining traffic

NOTE: the Above ACL rules should not affect the other communication

NOTE:

Before creating the **ACL**, make sure that the routing configured is correct and all the three LAN devices are able to communicate with each other using **PING** command

PC>ipconfig

IP Address.....: 192.168.1.1
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 192.168.1.100

PC>ping 192.168.2.1

Pinging 192.168.2.1 with 32 bytes of data:
Reply from 192.168.2.1: bytes=32 time=17ms TTL=126
Reply from 192.168.2.1: bytes=32 time=20ms TTL=126
Reply from 192.168.2.1: bytes=32 time=16ms TTL=126
Reply from 192.168.2.1: bytes=32 time=17ms TTL=126

```
PC>ipconfig
IP Address.....: 192.168.1.2
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 192.168.1.100
```

```
PC>ping 192.168.2.1
Pinging 192.168.2.1 with 32 bytes of data:
Reply from 192.168.2.1: bytes=32 time=16ms TTL=126
Reply from 192.168.2.1: bytes=32 time=22ms TTL=126
Reply from 192.168.2.1: bytes=32 time=23ms TTL=126
Reply from 192.168.2.1: bytes=32 time=11ms TTL=126
```

```
PC>ipconfig
IP Address.....: 192.168.3.1
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 192.168.3.100
```

```
PC>ping 192.168.2.1
Pinging 192.168.2.1 with 32 bytes of data:
Reply from 192.168.2.1: bytes=32 time=21ms TTL=126
Reply from 192.168.2.1: bytes=32 time=23ms TTL=126
Reply from 192.168.2.1: bytes=32 time=22ms TTL=126
Reply from 192.168.2.1: bytes=32 time=23ms TTL=126
```

ROUTER – 2

Creating the ACL rules according to requirement:

```
R-2(config)# access-list 15 deny 192.168.1.1 0.0.0.0
R-2(config)#access-list 15 deny host 192.168.1.2
R-2(config)#access-list 15 deny 192.168.3.0 0.0.0.255
R-2(config)#access-list 15 permit any
```

Implementation:

```
R-2(config)#interface fastEthernet 0/0
R-2(config-if)#ip access-group 15 out
```

Verification:

```
R-2#sh access-lists
Standard IP access list 15
deny host 192.168.1.1
deny host 192.168.1.2
deny 192.168.3.0 0.0.0.255
permit any
```

```
PC>ipconfig
IP Address.....: 192.168.1.1
```


Subnet Mask.....: 255.255.255.0

Default Gateway.....: 192.168.1.100

PC>ping 192.168.2.1

Pinging 192.168.2.1 with 32 bytes of data:

Reply from 10.0.0.2: Destination host unreachable.

Reply from 10.0.0.2: Destination host unreachable.

Reply from 10.0.0.2: Destination host unreachable.

Reply from 10.0.0.2: Destination host unreachable.

PC>ping 192.168.3.1

Pinging 192.168.3.1 with 32 bytes of data:

Reply from 192.168.3.1: bytes=32 time=21ms TTL=125

Reply from 192.168.3.1: bytes=32 time=17ms TTL=125

Reply from 192.168.3.1: bytes=32 time=24ms TTL=125

Reply from 192.168.3.1: bytes=32 time=13ms TTL=125

PC>ipconfig

IP Address.....: 192.168.1.2

Subnet Mask.....: 255.255.255.0

Default Gateway.....: 192.168.1.100

PC>ping 192.168.2.1

Pinging 192.168.2.1 with 32 bytes of data:

Reply from 10.0.0.2: Destination host unreachable.

Reply from 10.0.0.2: Destination host unreachable.

Reply from 10.0.0.2: Destination host unreachable.

Reply from 10.0.0.2: Destination host unreachable.

PC>ipconfig

IP Address.....: 192.168.1.3

Subnet Mask.....: 255.255.255.0

Default Gateway.....: 192.168.1.100

PC>ping 192.168.2.1

Pinging 192.168.2.1 with 32 bytes of data:

Reply from 192.168.2.1: bytes=32 time=31ms TTL=126

Reply from 192.168.2.1: bytes=32 time=17ms TTL=126

Reply from 192.168.2.1: bytes=32 time=23ms TTL=126

Reply from 192.168.2.1: bytes=32 time=24ms TTL=126

PC>ipconfig

IP Address.....: 192.168.3.1

Subnet Mask.....: 255.255.255.0

Default Gateway.....: 192.168.3.100

PC>ping 192.168.2.1

Pinging 192.168.2.1 with 32 bytes of data:

Reply from 11.0.0.1: Destination host unreachable.

Reply from 11.0.0.1: Destination host unreachable.

Reply from 11.0.0.1: Destination host unreachable.

Reply from 11.0.0.1: Destination host unreachable.

PC>ping 192.168.1.1

Pinging 192.168.1.1 with 32 bytes of data:

Reply from 192.168.1.1: bytes=32 time=16ms TTL=125

Reply from 192.168.1.1: bytes=32 time=29ms TTL=125

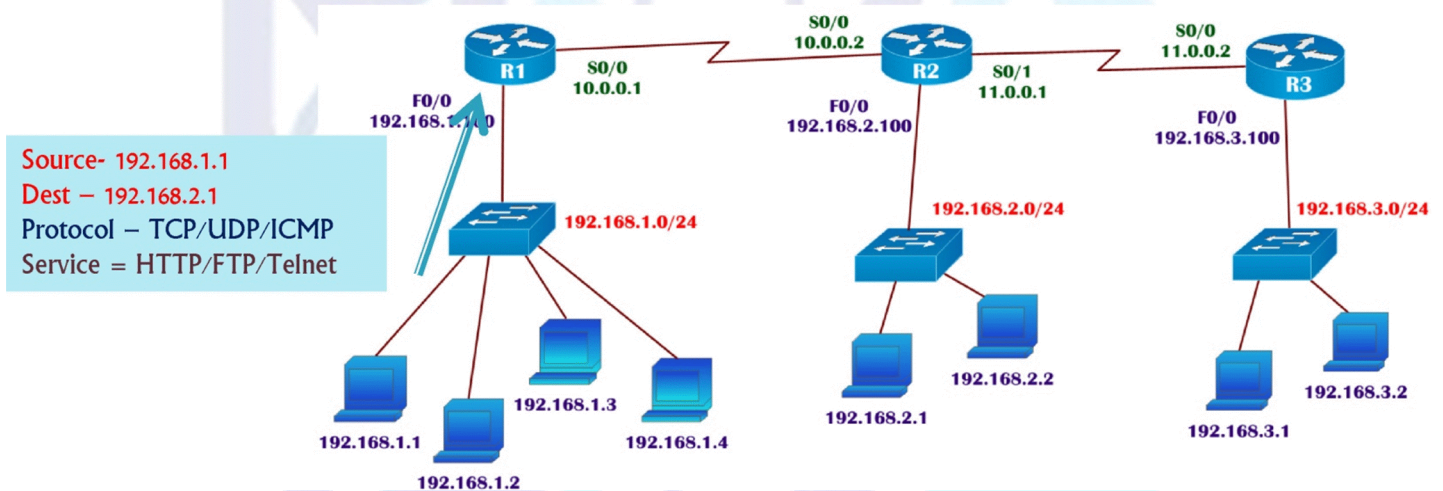
Reply from 192.168.1.1: bytes=32 time=16ms TTL=125

Reply from 192.168.1.1: bytes=32 time=21ms TTL=125



Extended Access-list

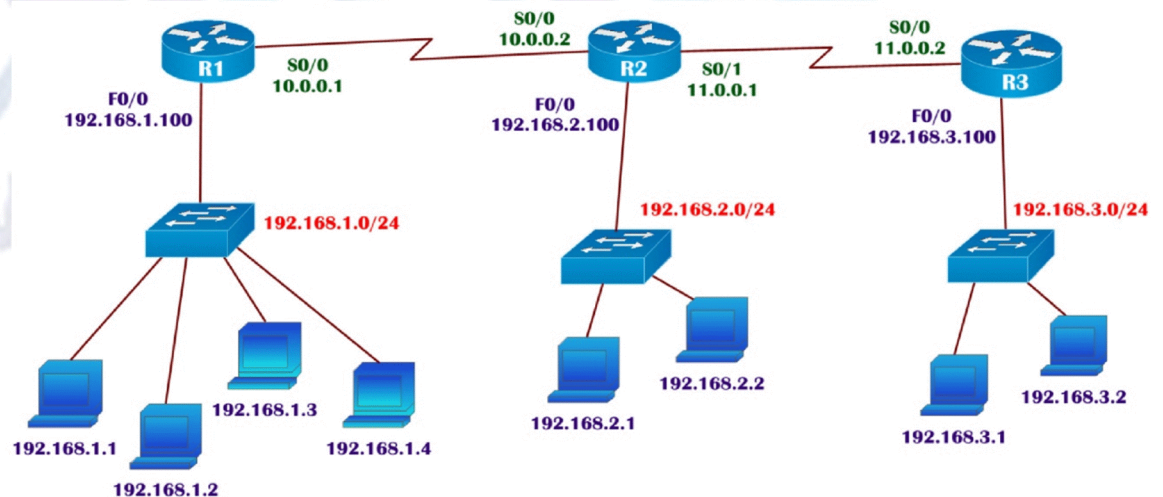
- ▶ Can be named or numbered.
- ▶ The access-list number range is 100 – 199 (or 2000-2699)
- ▶ We can allow or deny a Network, Host, Subnet and Service
- ▶ Selected services can be blocked.
- ▶ Filtering is done based on source IP , destination IP , protocol, port no



TASK: Configure the Appropriate router as per the rules given below

1. Deny the users on LAN 192.168.2.0 should not access 192.168.1.3 HTTP service
2. Deny the users on LAN 192.168.3.0 should not access 192.168.1.4 FTP service
3. Deny the users on LAN 192.168.3.1 should not access 192.168.1.3 HTTP service
4. Deny the users on LAN 192.168.2.0 should not get DNS service from DNS server 192.168.1.4
5. Deny the users from the host between 192.168.3.2 and 192.168.1.2 should not be able to send ICMP (ping /trace) messages
6. Remaining hosts and services should be permitted

NOTE: the Above ACL rules should not affect the other communication

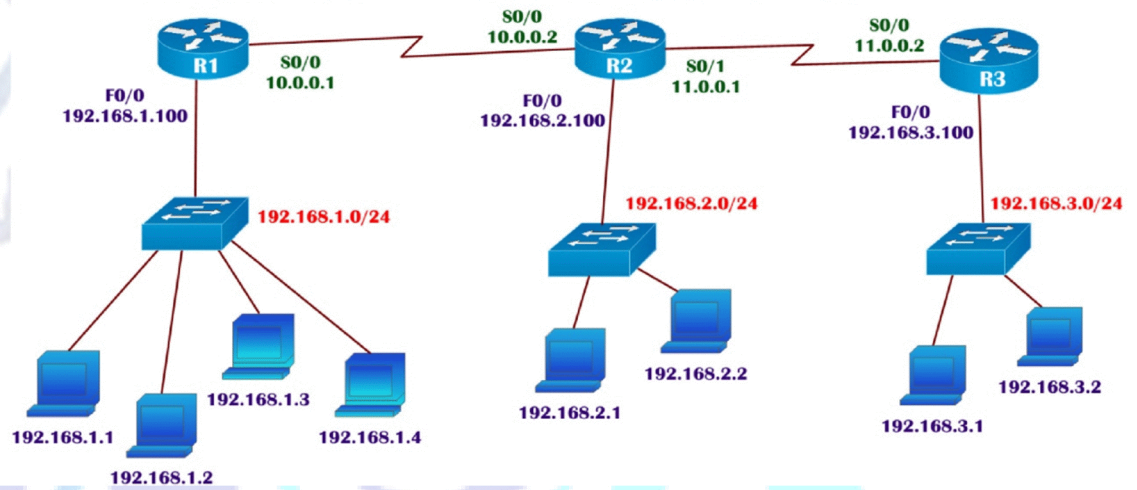


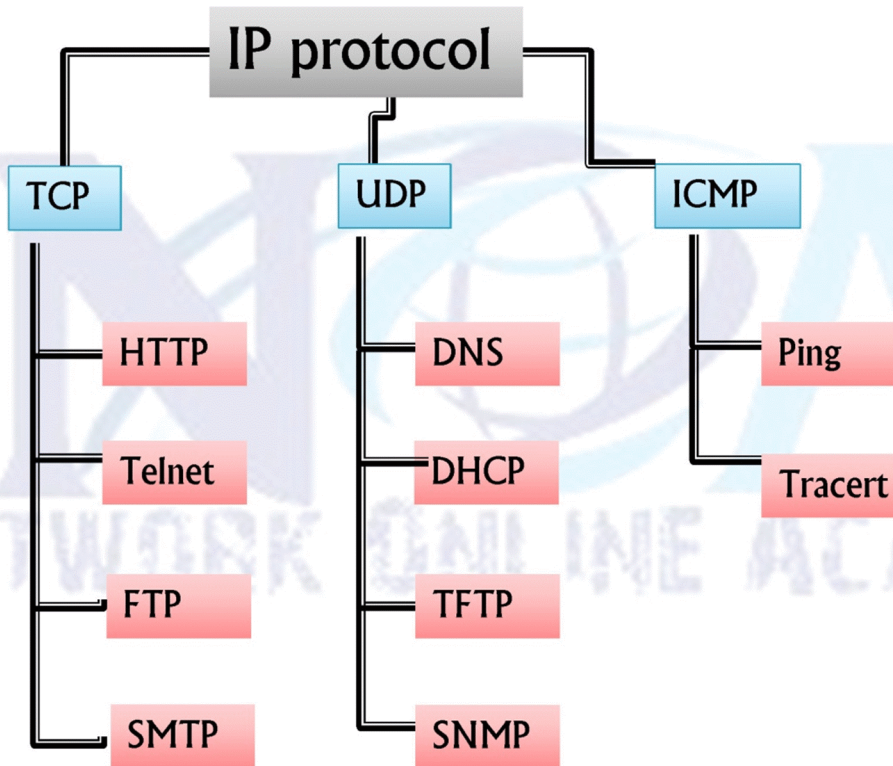
To write ACL Statement

- ▶ On which Router to implement ACL
- ▶ Identify Source & Destination

Ensure that the router you are implementing ACL must be the transit router . (R1)

	Source	Destination	service
1)	Deny - 192.168.2.0	- 192.168.1.3	HTTP
2)	Deny - 192.168.3.0	- 192.168.1.4	FTP
3)	Deny - 192.168.3.1	- 192.168.1.3	HTTP
4)	Deny - 192.168.2.0	- 192.168.1.4	DNS
5)	Deny - 192.168.3.2	- 192.168.1.1	PING
6)	Permit	any	





Operators used in extended ACL

= Equal to = **eq**

≠ Not Equal to = **neq**

> Greater than = **gt**

< lesser than = **lt**

R-1(config)#access-list 145 deny tcp 192.168.2.0 0.0.0.255 host 192.168.1.3 eq www

R-1(config)#access-list 145 deny tcp 192.168.3.0 0.0.0.255 host 192.168.1.4 eq ftp

R-1(config)#access-list 145 deny tcp host 192.168.3.1 host 192.168.1.3 eq www

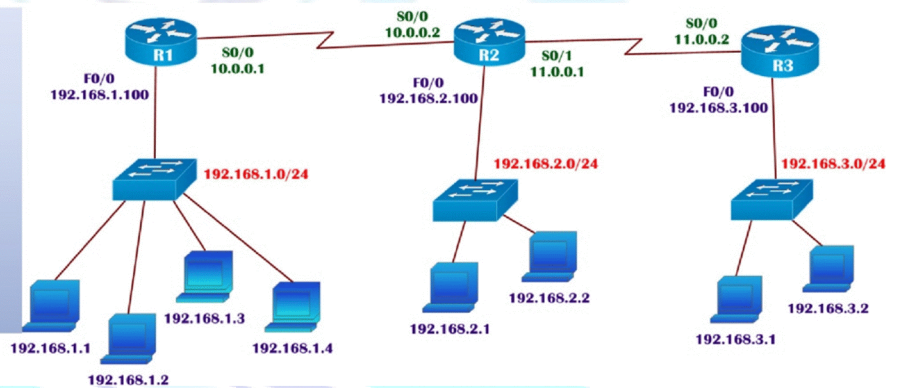
R-1(config)#access-list 145 deny udp 192.168.2.0 0.0.0.255 host 192.168.1.4 eq domain

R-1(config)#access-list 145 deny icmp host 192.168.3.2 host 192.168.1.2 echo

R-1(config)#access-list 145 deny icmp host 192.168.3.2 host 192.168.1.2 echo-reply

R-1(config)#access-list 145 permit ip any any

	Source	Destination	service
1)	Deny	- 192.168.2.0 - 192.168.1.3	HTTP
2)	Deny	- 192.168.3.0 - 192.168.1.4	FTP
3)	Deny	- 192.168.3.1 - 192.168.1.3	HTTP
4)	Deny	- 192.168.2.0 - 192.168.1.4	DNS
5)	Deny	- 192.168.3.2 - 192.168.1.1	PING
6)	Permit	any	any

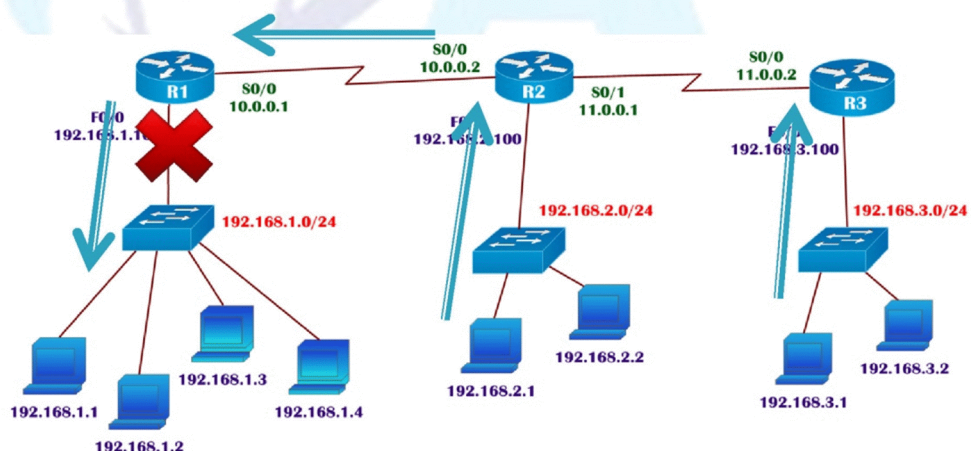


NETWORK ONLINE ACADEMY

Implementation:

```
R-1(config)# interface fastEthernet 0/0
R-1(config-if)# ip access-group 145 out
```

	Source	Destination	service
1)	Deny	- 192.168.2.0 - 192.168.1.3	HTTP
2)	Deny	- 192.168.3.0 - 192.168.1.4	FTP
3)	Deny	- 192.168.3.1 - 192.168.1.3	HTTP
4)	Deny	- 192.168.2.0 - 192.168.1.4	DNS
5)	Deny	- 192.168.3.2 - 192.168.1.1	PING
6)	Permit	any	any



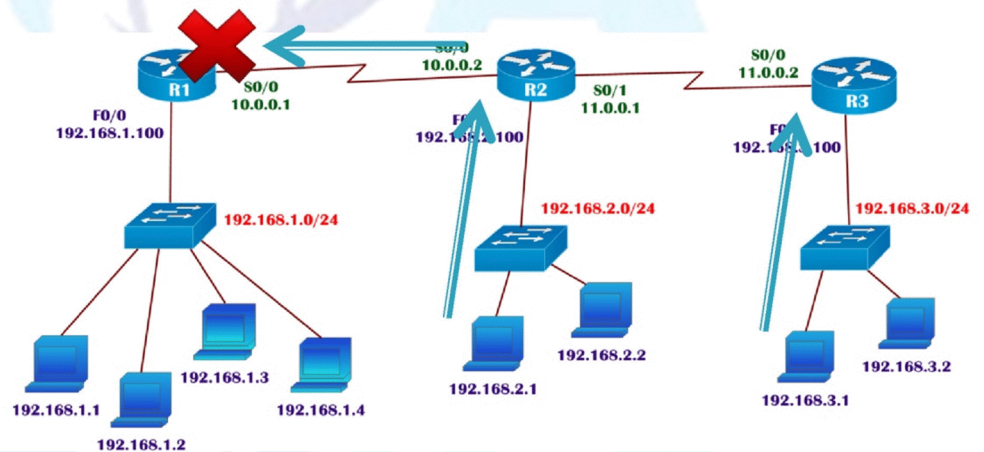
Implementation:

OR

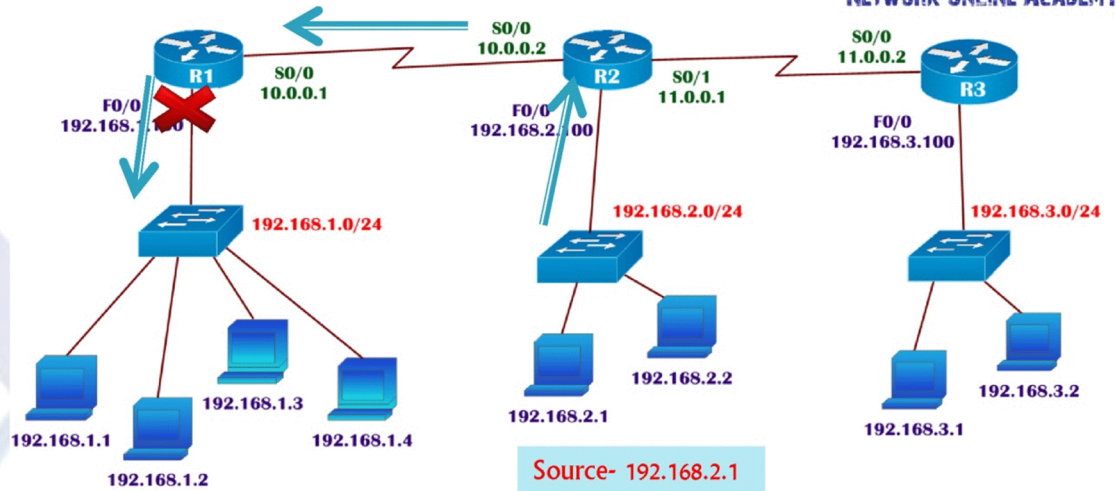
R-1(config)# interface serial 0/0

R-1(config-if)# ip access-group 145 in

	Source	Destination	service
1)	Deny	- 192.168.2.0 - 192.168.1.3	HTTP
2)	Deny	- 192.168.3.0 - 192.168.1.4	FTP
3)	Deny	- 192.168.3.1 - 192.168.1.3	HTTP
4)	Deny	- 192.168.2.0 - 192.168.1.4	DNS
5)	Deny	- 192.168.3.2 - 192.168.1.1	PING
6)	Permit	any	any



Extended ACL verification

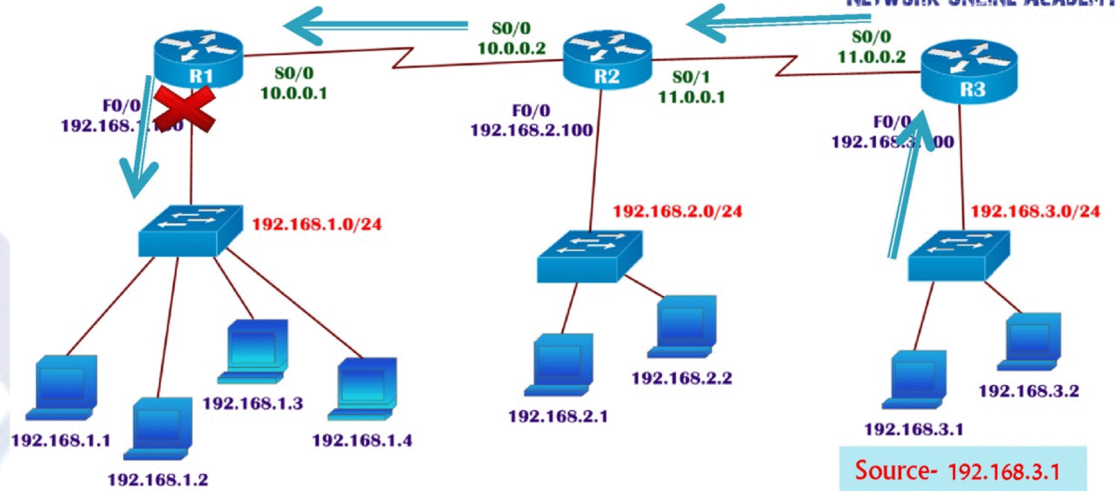


Source- 192.168.2.1
Dest - 192.168.1.3
Protocol - TCP
Service = HTTP

	Source	Destination	service
1)	Deny - 192.168.2.0 - 192.168.1.3		HTTP
2)	Deny - 192.168.3.0 - 192.168.1.4		FTP
3)	Deny - 192.168.3.1 - 192.168.1.3		HTTP
4)	Deny - 192.168.2.0 - 192.168.1.4		DNS
5)	Deny - 192.168.3.2 - 192.168.1.1		PING
6)	Permit any	any	

NETWORK ONLINE ACADEMY

Extended ACL verification

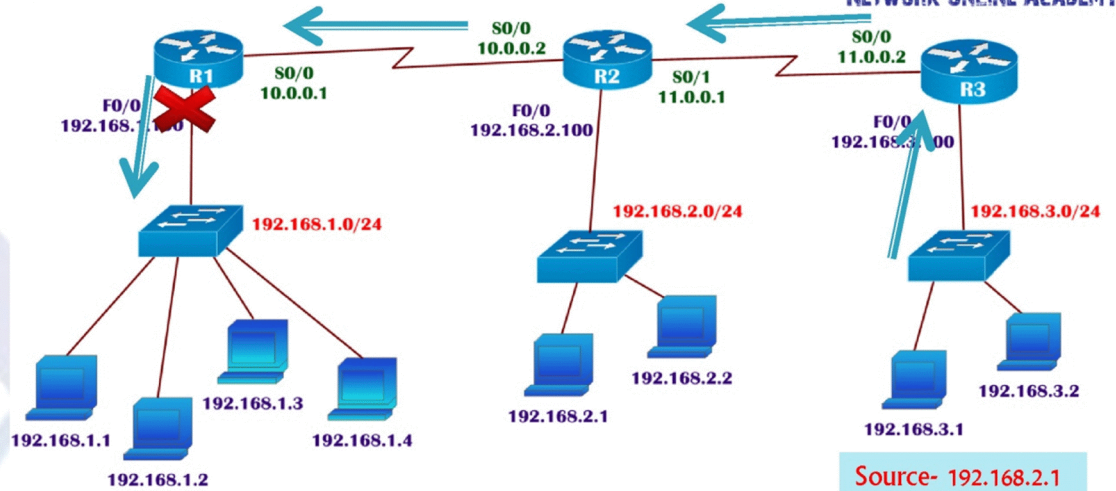


Source- 192.168.3.1
Dest - 192.168.1.4
Protocol - TCP
Service = FTP

	Source	Destination	service
1)	Deny - 192.168.2.0 - 192.168.1.3		HTTP
2)	Deny - 192.168.3.0 - 192.168.1.4		FTP
3)	Deny - 192.168.3.1 - 192.168.1.3		HTTP
4)	Deny - 192.168.2.0 - 192.168.1.4		DNS
5)	Deny - 192.168.3.2 - 192.168.1.1		PING
6)	Permit any	any	

NETWORK ONLINE ACADEMY

Extended ACL verification

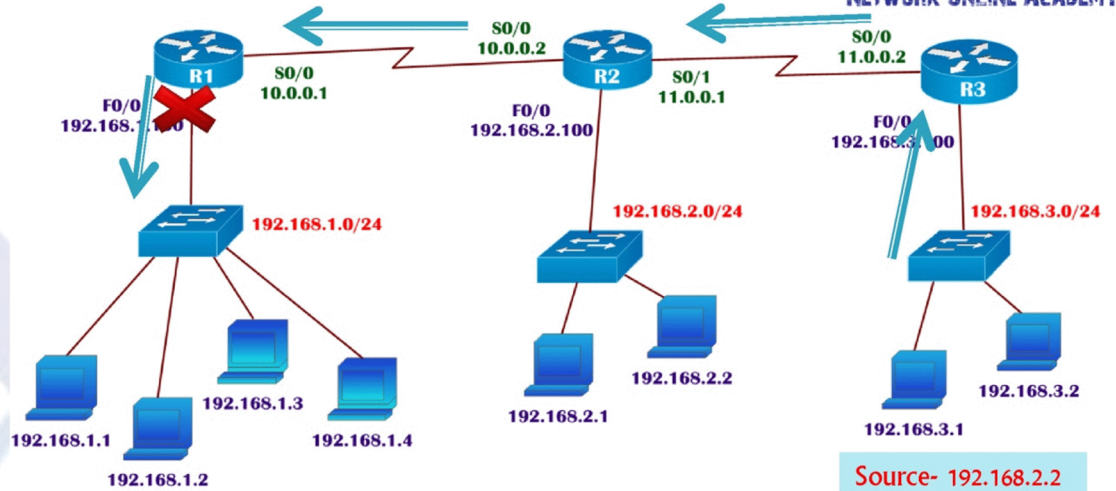


Source- 192.168.2.1
Dest - 192.168.1.4
Protocol - UDP
Service = DNS

	Source	Destination	service
1)	Deny - 192.168.2.0 - 192.168.1.3		HTTP
2)	Deny - 192.168.3.0 - 192.168.1.4		FTP
3)	Deny - 192.168.3.1 - 192.168.1.3		HTTP
4)	Deny - 192.168.2.0 - 192.168.1.4		DNS
5)	Deny - 192.168.3.2 - 192.168.1.1		PING
6)	Permit any	any	

NETWORK ONLINE ACADEMY

Extended ACL verification

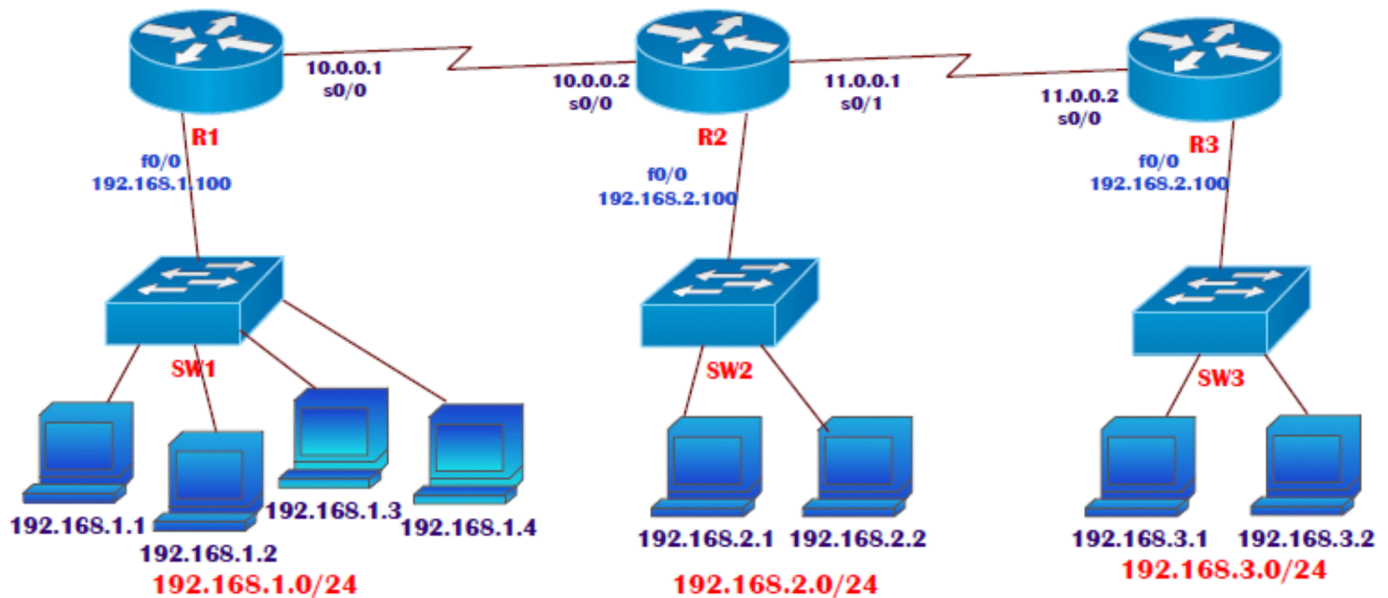


Source- 192.168.2.2
Dest - 192.168.1.4
Protocol - TCP
Service = HTTP

	Source	Destination	service
1)	Deny - 192.168.2.0 - 192.168.1.3		HTTP
2)	Deny - 192.168.3.0 - 192.168.1.4		FTP
3)	Deny - 192.168.3.1 - 192.168.1.3		HTTP
4)	Deny - 192.168.2.0 - 192.168.1.4		DNS
5)	Deny - 192.168.3.2 - 192.168.1.1		PING
6)	Permit any	any	

NETWORK ONLINE ACADEMY

LAB: EXTENDED ACCESS-LIST



Pre-requirement for LAB (check previous labs)

- 1) Design the topology (connectivity)
- 2) Assign the IP address according to diagram
- 3) Make sure that interfaces used should be in UP state
- 4) Any dynamic routing Protocol or static routing
- 5) Verify Routing table and reachability between the LAN's (using PING and TRACE commands)

TASK: Configure the Appropriate router as per the rules given below

1. Deny the users on LAN 192.168.2.0 should not access 192.168.1.3 HTTP service
2. Deny the users on LAN 192.168.3.0 should not access 192.168.1.4 FTP service
3. Deny the users on LAN 192.168.3.1 should not access 192.168.1.3 HTTP service
4. Deny the users on LAN 192.168.2.0 should not get DNS service from DNS server 192.168.1.4
5. Deny the users from the host between 192.168.3.2 and 192.168.1.2 should not be able to send ICMP (ping/trace) messages
6. Remaining hosts and services should be permitted

NOTE: the Above ACL rules should not affect the other communication

Router – 1

```
R-1(config)#access-list 145 deny tcp 192.168.2.0 0.0.0.255 host 192.168.1.3 eq www
```

```
R-1(config)#access-list 145 deny tcp 192.168.3.0 0.0.0.255 host 192.168.1.4 eq ftp
```

```
R-1(config)#access-list 145 deny tcp host 192.168.3.1 host 192.168.1.3 eq www
```

```
R-1(config) #access-list 145 deny udp 192.168.2.0 0.0.0.255 host 192.168.1.4 eq ?
```

<0-65535> Port number
bootpc Bootstrap Protocol (BOOTP) client (68)

bootps	Bootstrap Protocol (BOOTP) server (67)
domain	Domain Name Service (DNS, 53)
isakmp	Internet Security Association and Key Management Protocol (500)
non500-isakmp	Internet Security Association and Key Management Protocol (4500)
snmp	Simple Network Management Protocol (161)
tftp	Trivial File Transfer Protocol (69)

```
R-1(config)#access-list 145 deny udp 192.168.2.0 0.0.0.255 host 192.168.1.4 eq domain
```

```
R-1(config)#access-list 145 deny icmp host 192.168.3.1 host 192.168.1.1 ?
```

<0-256>	type-num
echo	echo
echo-reply	echo-reply
host-unreachable	host-unreachable
net-unreachable	net-unreachable
port-unreachable	port-unreachable
protocol-unreachable	protocol-unreachable
ttl-exceeded	ttl-exceeded
unreachable	unreachable
<cr>	

```
R-1(config)#access-list 145 deny icmp host 192.168.3.2 host 192.168.1.2 echo
```

```
R-1(config)#access-list 145 deny icmp host 192.168.3.2 host 192.168.1.2 echo-reply
```

```
R-1(config)#access-list 145 permit ip any any
```

Implementation:

```
R-1(config)# interface fastEthernet 0/0
```

```
R-1(config-if)# ip access-group 145 out
```

OR

```
R-1(config)# interface serial 0/0
```

```
R-1(config-if)# ip access-group 145 in
```

Verification:

```
PC>ipconfig
```

```
IP Address.....: 192.168.3.2
```

```
Subnet Mask.....: 255.255.255.0
```

```
Default Gateway.....: 192.168.3.100
```

```
PC>ping 192.168.1.2
```

```
Pinging 192.168.1.2 with 32 bytes of data:
```

```
Request timed out.
```

```
Request timed out.
```

```
Request timed out.
```

```
Request timed out.
```


PC>ping 192.168.1.1

Pinging 192.168.1.1 with 32 bytes of data:

Reply from 192.168.1.1: bytes=32 time=20ms TTL=125

Reply from 192.168.1.1: bytes=32 time=27ms TTL=125

Reply from 192.168.1.1: bytes=32 time=13ms TTL=125

Reply from 192.168.1.1: bytes=32 time=25ms TTL=125



Named ACL

- ▶ Access-lists are identified using Names (instead of Numbers).
- ▶ Names are Case-Sensitive.
- ▶ No limitation of Numbers here.
- ▶ One Main Advantage is Editing of ACL is Possible (i.e) Removing a specific statement from the ACL is possible.

1. Deny 192.168.1.0 = 192.168.2.1 HTTP
2. Deny 192.168.3.0 = 192.168.2.2 FTP
3. Permit any

ACL - 120 - Numbered ACL

ACL - CCNA Named ACL

Named ACL - Standard

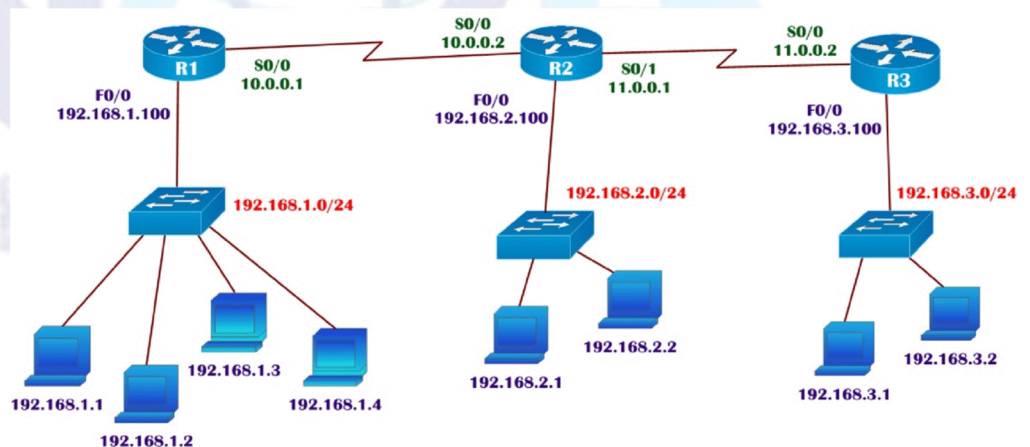
Router(config)# **ip access-list standard** <name>

Router(config-std-nacl)# <permit/deny> <source address> <source wildcard mask>

Implementation

Router(config)# **interface** <interface type><interface no>

Router(config-if)# **ip access-group** <name> <out/in>



Named ACL - Extended

Router(config)# **ip access-list extended** <name>

Router(config-ext-nacl)#

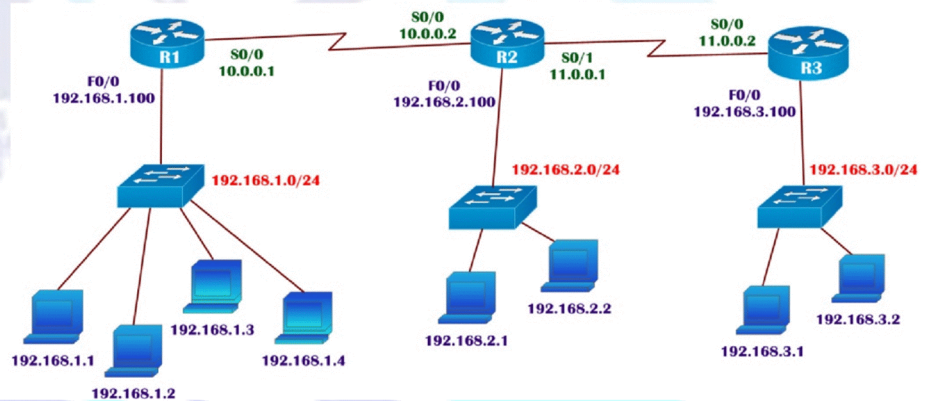
<permit/deny> <protocol> <source address> <source wildcard mask> <destination address>

< destination wildcard mask> <operator> <service>

Implementation

Router(config)# **interface** <interface type><interface no>

Router(config-if)# **ip access-group** <name> <out/in>



Editing named ACL

```
Router(config)#ip access-list standard CCNA
Router(config-std-nacl)#deny host 192.168.1.1
Router(config-std-nacl)#deny host 192.168.1.2
Router(config-std-nacl)#deny 192.168.3.0 0.0.0.255
Router(config-std-nacl)#permit any
```

Router#sh ip access-lists

Standard IP access list CCNA

```
10 deny host 192.168.1.1
20 deny host 192.168.1.2
30 deny 192.168.3.0 0.0.0.255
40 permit any
```

```
Router(config)#ip access-list standard CCNA
Router(config-std-nacl)#23 deny host 192.168.1.3
Router(config-std-nacl)#35 deny 192.168.4.0 0.0.0.255
Router(config-std-nacl)#exit
```

Router#sh ip access-lists

Standard IP access list CCNA

```
10 deny host 192.168.1.1
20 deny host 192.168.1.2
23 deny host 192.168.1.3
30 deny 192.168.3.0 0.0.0.255
35 deny 192.168.4.0 0.0.0.255
40 permit any
```

Editing named ACL

```
Router(config)#ip access-list standard CCNA
Router(config-std-nacl)#no 30
Router(config-std-nacl)#no 35
Router(config-std-nacl)#exit
```

Router#sh ip access-lists

Standard IP access list CCNA

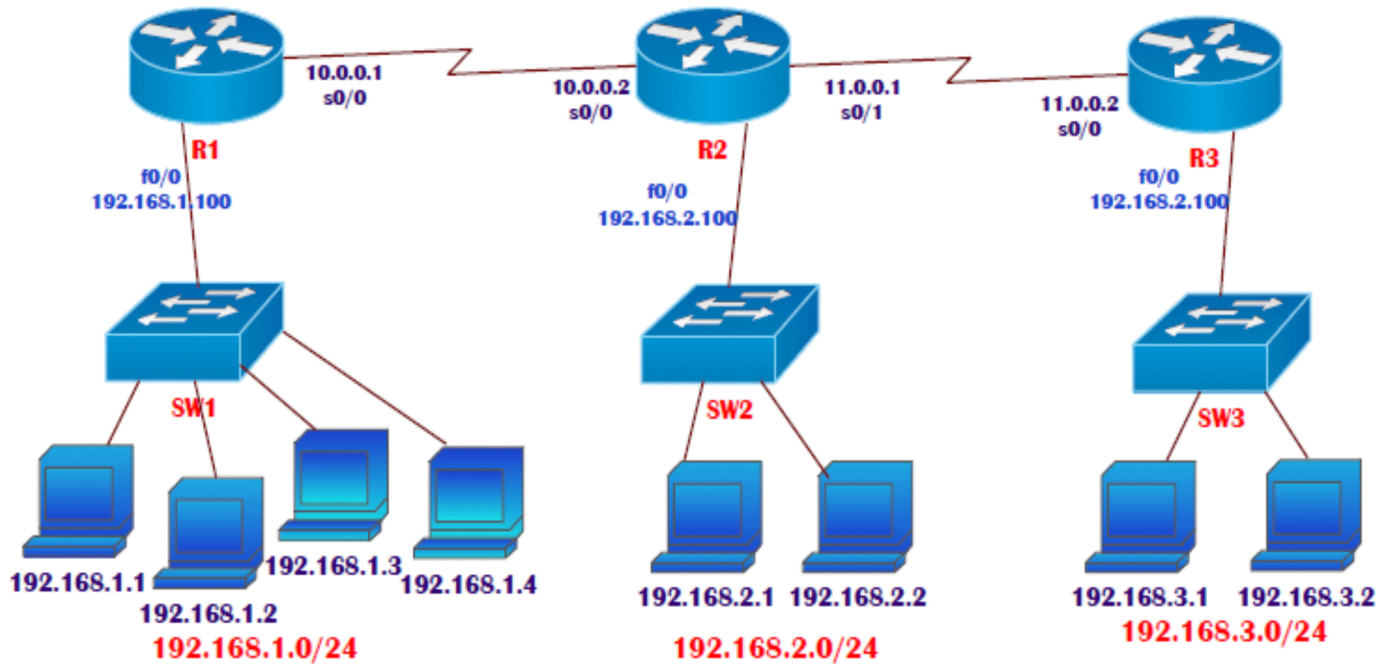
```
10 deny host 192.168.1.1
20 deny host 192.168.1.2
23 deny host 192.168.1.3
30 deny 192.168.3.0 0.0.0.255
35 deny 192.168.4.0 0.0.0.255
40 permit any
```

Router#sh ip access-lists

Standard IP access list CCNA

```
10 deny host 192.168.1.1
20 deny host 192.168.1.2
23 deny host 192.168.1.3
40 permit any
```

LAB: STANDARD NAMED ACL



TASK:

- Configure Standard Named ACL
- Use the same Rules as Lab-1

Before creating the ACL, make sure that the routing configured is correct and all the three LAN devices are able to communicate with each other using PING command

```
PC>ipconfig
IP Address.....: 192.168.1.1
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 192.168.1.100
```

```
PC>ping 192.168.2.1
Pinging 192.168.2.1 with 32 bytes of data:
Reply from 192.168.2.1: bytes=32 time=17ms TTL=126
Reply from 192.168.2.1: bytes=32 time=20ms TTL=126
Reply from 192.168.2.1: bytes=32 time=16ms TTL=126
Reply from 192.168.2.1: bytes=32 time=17ms TTL=126
```

```
PC>ipconfig
IP Address.....: 192.168.1.2
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 192.168.1.100
```

```
PC>ping 192.168.2.1
Pinging 192.168.2.1 with 32 bytes of data:
```

Reply from 192.168.2.1: bytes=32 time=16ms TTL=126
Reply from 192.168.2.1: bytes=32 time=22ms TTL=126
Reply from 192.168.2.1: bytes=32 time=23ms TTL=126
Reply from 192.168.2.1: bytes=32 time=11ms TTL=126

```
PC>ipconfig
IP Address.....: 192.168.3.1
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 192.168.3.100
```

```
PC>ping 192.168.2.1
Pinging 192.168.2.1 with 32 bytes of data:
Reply from 192.168.2.1: bytes=32 time=21ms TTL=126
Reply from 192.168.2.1: bytes=32 time=23ms TTL=126
Reply from 192.168.2.1: bytes=32 time=22ms TTL=126
Reply from 192.168.2.1: bytes=32 time=23ms TTL=126
```

Creating an Access-list as per the given rules

```
R-2(config)#ip access-list standard CCNA
R-2(config-std-nacl)#deny 192.168.1.1 0.0.0.0
R-2(config-std-nacl)#deny host 192.168.1.2
R-2(config-std-nacl)#deny 192.168.3.0 0.0.0.255
R-2(config-std-nacl)#permit any
R-2(config-std-nacl)#exit
```

Implementation:

```
R-2(config)# interface fastEthernet 0/0
R-2(config-if)# ip access-group CCNA out
```

```
R-2#sh access-lists
Standard IP access list CCNA
deny host 192.168.1.1
deny host 192.168.1.2
deny 192.168.3.0 0.0.0.255
permit any
```

```
PC>ipconfig
IP Address.....: 192.168.1.1
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 192.168.1.100
```

```
PC>ping 192.168.2.1

Pinging 192.168.2.1 with 32 bytes of data:
Reply from 10.0.0.2: Destination host unreachable.
```


Reply from 10.0.0.2: Destination host unreachable.
Reply from 10.0.0.2: Destination host unreachable.
Reply from 10.0.0.2: Destination host unreachable.

PC>ping 192.168.3.1

Pinging 192.168.3.1 with 32 bytes of data:
Reply from 192.168.3.1: bytes=32 time=21ms TTL=125
Reply from 192.168.3.1: bytes=32 time=17ms TTL=125
Reply from 192.168.3.1: bytes=32 time=24ms TTL=125
Reply from 192.168.3.1: bytes=32 time=13ms TTL=125

PC>ipconfig

IP Address.....: 192.168.1.2
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 192.168.1.100

PC>ping 192.168.2.1

Pinging 192.168.2.1 with 32 bytes of data:
Reply from 10.0.0.2: Destination host unreachable.
Reply from 10.0.0.2: Destination host unreachable.
Reply from 10.0.0.2: Destination host unreachable.
Reply from 10.0.0.2: Destination host unreachable.

SERVER>ipconfig

IP Address.....: 192.168.1.3
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 192.168.1.100

SERVER>ping 192.168.2.1

Pinging 192.168.2.1 with 32 bytes of data:
Reply from 192.168.2.1: bytes=32 time=31ms TTL=126
Reply from 192.168.2.1: bytes=32 time=17ms TTL=126
Reply from 192.168.2.1: bytes=32 time=23ms TTL=126
Reply from 192.168.2.1: bytes=32 time=24ms TTL=126

PC>ipconfig

IP Address.....: 192.168.3.1
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 192.168.3.100

PC>ping 192.168.2.1

Pinging 192.168.2.1 with 32 bytes of data:
Reply from 11.0.0.1: Destination host unreachable.
Reply from 11.0.0.1: Destination host unreachable.
Reply from 11.0.0.1: Destination host unreachable.
Reply from 11.0.0.1: Destination host unreachable.

PC>ping 192.168.1.1

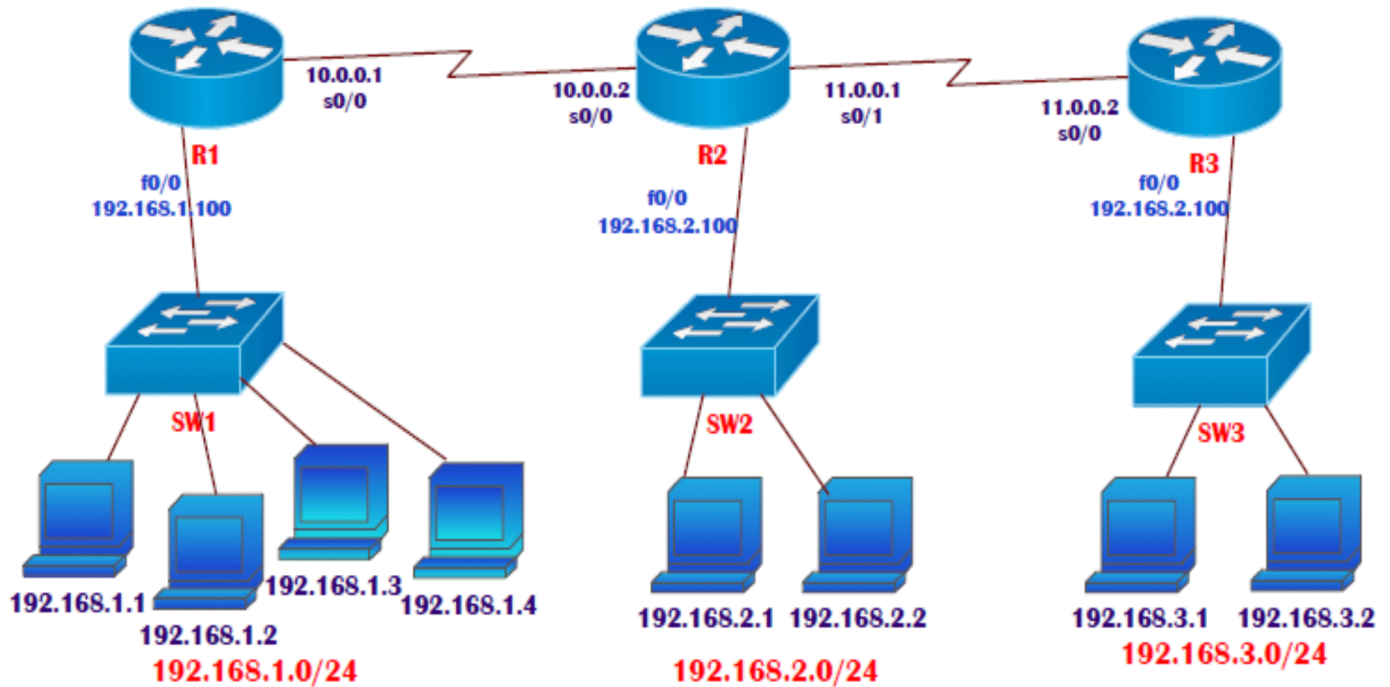
Pinging 192.168.1.1 with 32 bytes of data:
Reply from 192.168.1.1: bytes=32 time=16ms TTL=125
Reply from 192.168.1.1: bytes=32 time=29ms TTL=125

Reply from 192.168.1.1: bytes=32 time=16ms TTL=125

Reply from 192.168.1.1: bytes=32 time=21ms TTL=125



LAB: NAMED EXTENDED ACL



TASK:

- Configure Standard Named ACL
- Use the same Rules as Lab-2

```
R1(config)#ip access-list extended CCNP
```

```
R1(config-ext-nacl)#deny tcp 192.168.2.0 0.0.0.255 host 192.168.1.3 eq www
```

```
R1(config-ext-nacl)# deny tcp 192.168.3.0 0.0.0.255 host 192.168.1.4 eq ftp
```

```
R1(config-ext-nacl)# deny tcp host 192.168.3.1 host 192.168.1.3 eq www
```

```
R1(config-ext-nacl)#deny udp 192.168.2.0 0.0.0.255 host 192.168.1.4 eq domain
```

```
R1(config-ext-nacl)# deny icmp host 192.168.3.1 host 192.168.1.1 echo
```

```
R1(config-ext-nacl)#deny icmp host 192.168.3.1 host 192.168.1.1 echo-reply
```

```
R1(config-ext-nacl)# permit ip any any
```

Implementation:

```
R1(config)# interface fastEthernet 0/0
```

```
R1(config-if)# ip access-group CCNP out
```

OR

```
R1(config)# interface serial 0/0
```



```
R-1(config-if)# ip access-group CCNP in
```

R-1#sh access-lists

Extended IP access list CCNP

```
deny tcp 192.168.2.0 0.0.0.255 host 192.168.1.3 eq www
deny tcp 192.168.3.0 0.0.0.255 host 192.168.1.4 eq ftp
deny tcp host 192.168.3.1 host 192.168.1.3 eq www
deny udp 192.168.2.0 0.0.0.255 host 192.168.1.4 eq domain
deny icmp host 192.168.3.1 host 192.168.1.1 echo
deny icmp host 192.168.3.1 host 192.168.1.1 echo-reply
permit ip any any
```

Verification:

PC>ipconfig

```
IP Address.....: 192.168.3.2
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 192.168.3.100
```

PC>ping 192.168.1.2

Pinging 192.168.1.2 with 32 bytes of data:

Request timed out.

Request timed out.

Request timed out.

Request timed out.

PC>ping 192.168.1.1

Pinging 192.168.1.1 with 32 bytes of data:

Reply from 192.168.1.1: bytes=32 time=20ms TTL=125

Reply from 192.168.1.1: bytes=32 time=27ms TTL=125

Reply from 192.168.1.1: bytes=32 time=13ms TTL=125

Reply from 192.168.1.1: bytes=32 time=25ms TTL=125

Network Address Translation

Public IP

- ▶ Used on public network(INTERNET)
- ▶ Recognized on internet
- ▶ Given by the service provider (from IANA)
- ▶ Globally unique
- ▶ Pay to service provider (or IANA)
- ▶ Registered

Private IP

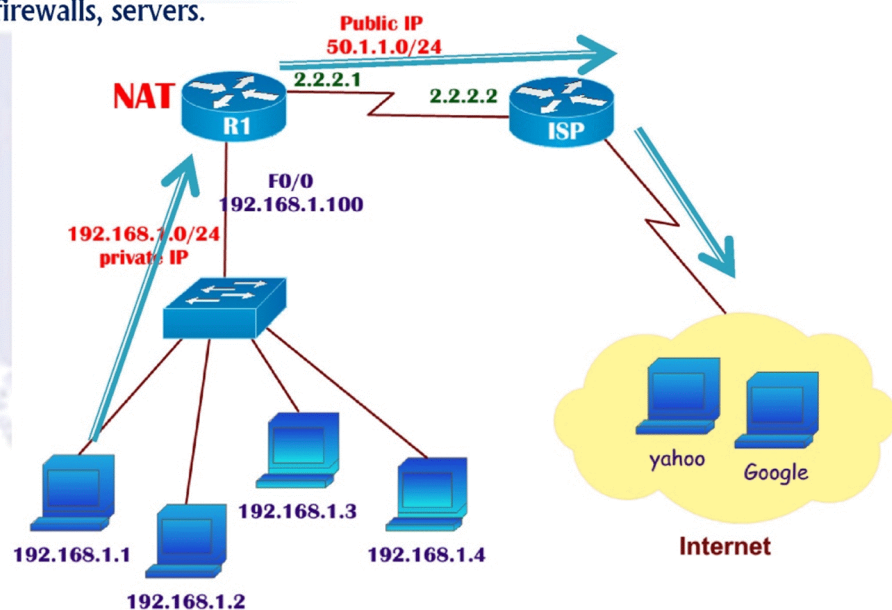
- ▶ Used with the LAN or within the organization
- ▶ Not recognized on internet
- ▶ Given by the administrator
- ▶ Unique within the network or organization
- ▶ Free
- ▶ Unregistered IP

Private IP Address

Class A	10.0.0.0	to	10.255.255.255	(10.x.x.x)
Class B	172.16.0.0	to	172.31.255.255	
Class C	192.168.0.0	to	192.168.255.255	(192.168.x.x)

Network address translation

- ▶ Method of translation of private IP to public IP address.
- ▶ In order to communicate with internet we must have registered public IP address.
- ▶ Can be configured on Routers, firewalls, servers.

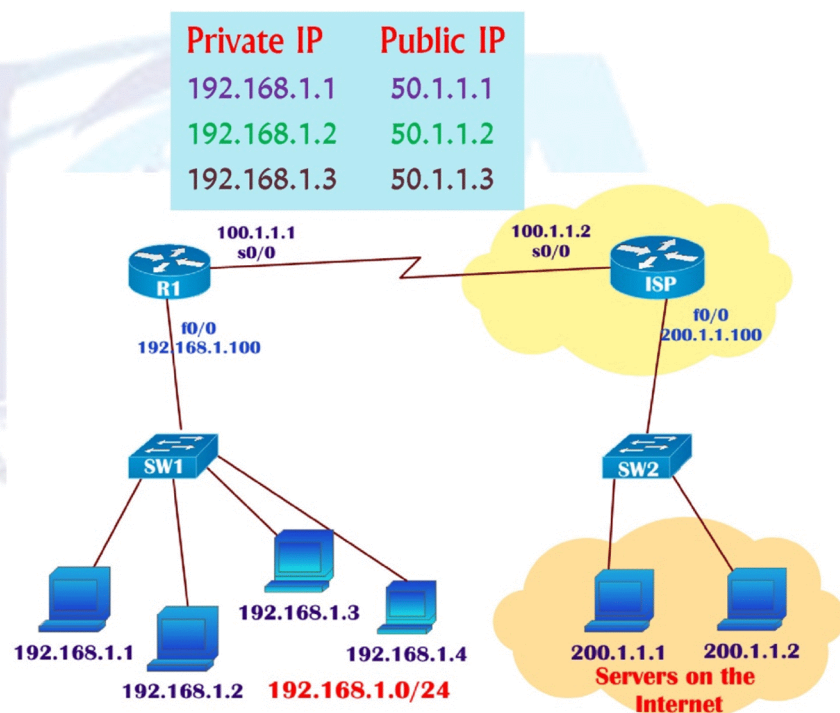


Types of NAT:-

- ▶ Static NAT
- ▶ Dynamic NAT
- ▶ Port Address Translation (PAT)

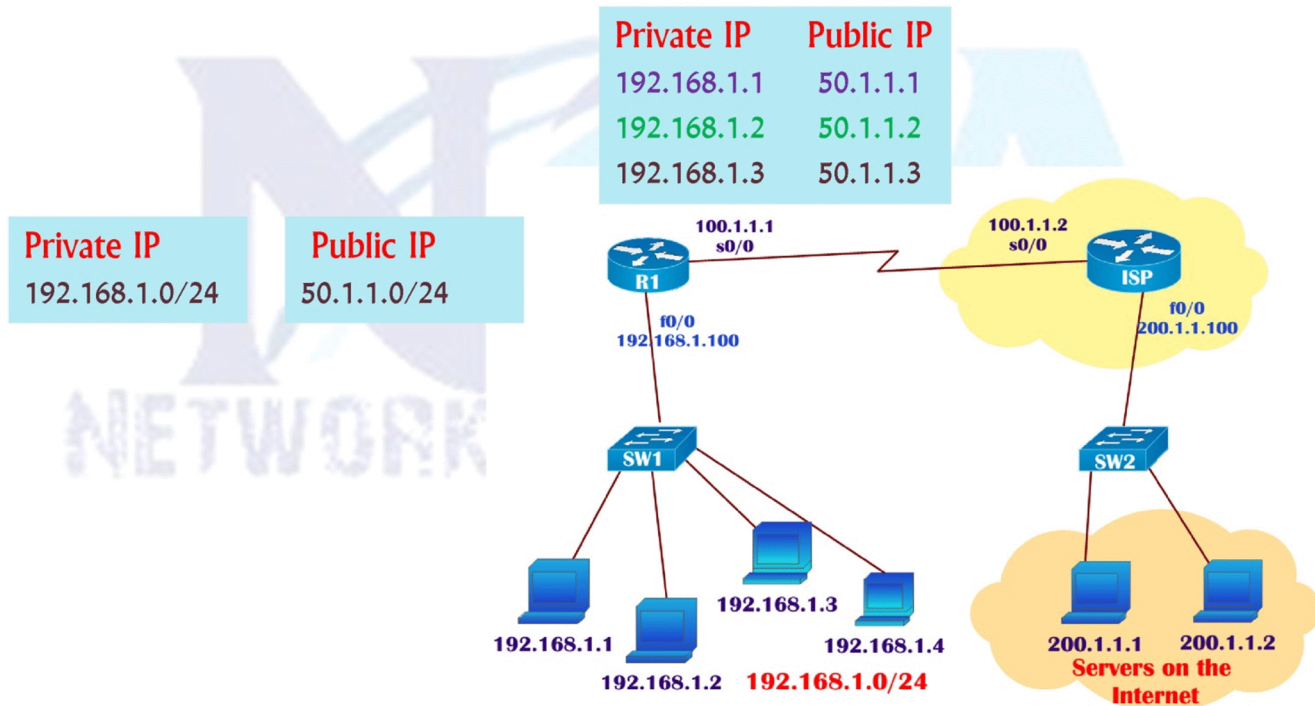
Static NAT

- ▶ One to one mapping done Manually
- ▶ Every private IP needs one registered public IP address (one : one)



Dynamic NAT

- ▶ One to one mapping done automatically by NAT device.
- ▶ For every private IP needs on registered IP address (one : one)

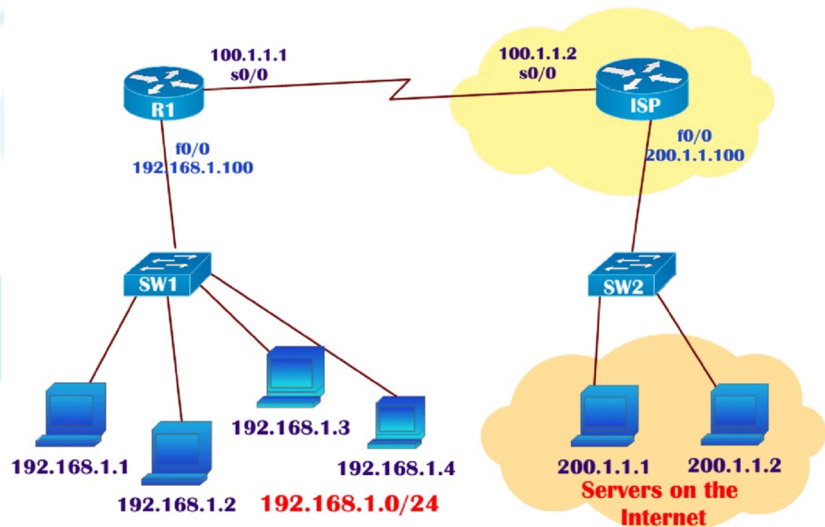


Port Address Translation (Dynamic NAT Overload)

- ▶ Thousands of private users – use single Public IP.
- ▶ Use port numbers mapped to single Public IP to differentiate connections.
- ▶ PAT is the real reason we haven't run out of valid IP address on the Internet.

Private IP	Public IP
192.168.1.1	50.1.1.1 : 2000
192.168.1.2	50.1.1.1 : 2001
192.168.1.3	50.1.1.1 : 2002

Private IP	Public IP
192.168.1.0/24	50.1.1.1/32

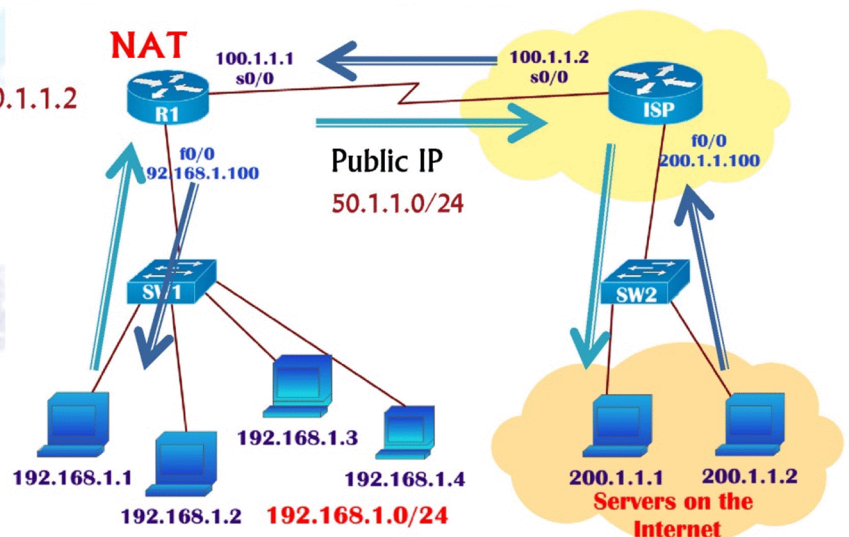


Lab setup for NAT

1. Configure IP address as per the diagram.
2. Configure default route towards ISP from R1
3. Configure static route from ISP to public IP used for translation

ISP(config)# **ip route 50.1.1.0 255.255.255.0 100.1.1.1**

R1(config)# **ip route 0.0.0.0 0.0.0.0 100.1.1.2**



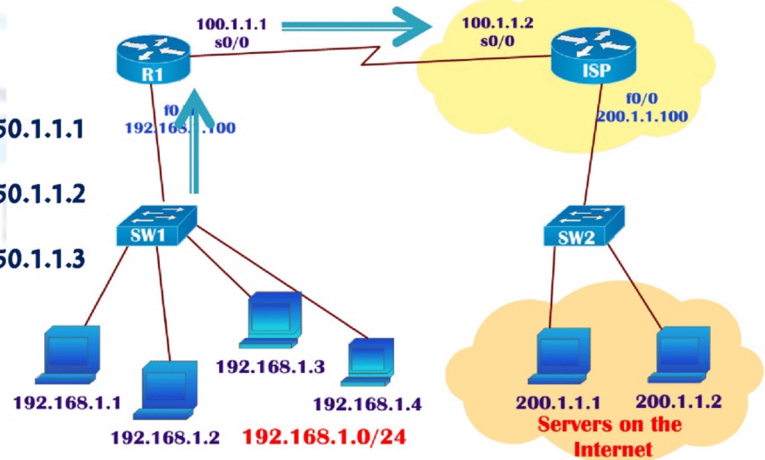
LAB : Static NAT

R-1(config)#ip nat inside source static <private-IP> <Public-IP>

PRIVATE - PUBLIC

192.168.1.1	-	50.1.1.1
192.168.1.2	-	50.1.1.2
192.168.1.3	-	50.1.1.3

R-1(config)#ip nat inside source static 192.168.1.1 50.1.1.1
R-1(config)#ip nat inside source static 192.168.1.2 50.1.1.2
R-1(config)#ip nat inside source static 192.168.1.3 50.1.1.3



LAB : Static NAT

Implementation

R-1(config)#interface fastEthernet 0/0
R-1(config-if)#ip nat inside
R-1(config-if)#exit
(interface facing towards LAN)

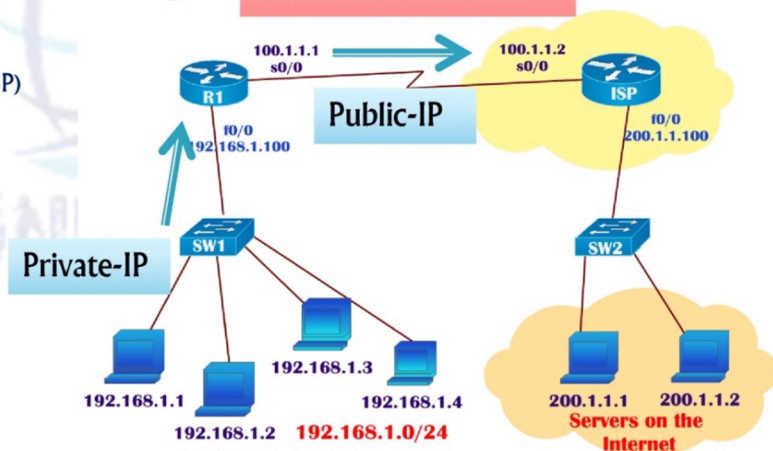
R-1(config)#interface serial 0/0
R-1(config-if)#ip nat outside
(Interface facing towards ISP)

To verify NAT

R-1#sh ip nat translations

PRIVATE - PUBLIC

192.168.1.1	-	50.1.1.1
192.168.1.2	-	50.1.1.2
192.168.1.3	-	50.1.1.3



LAB -1 STATIC NAT

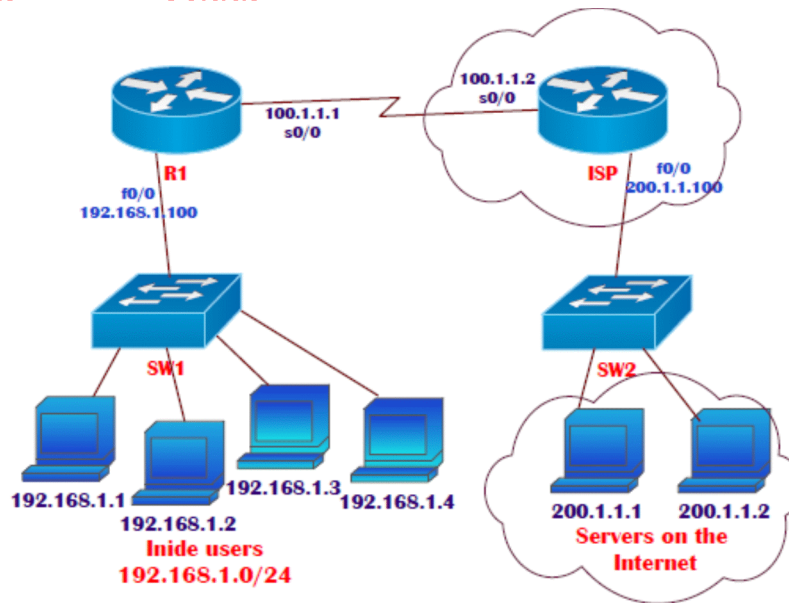
TASK: Configure Static NAT using the following translations

PRIVATE IP

192.168.1.1
192.168.1.2
192.168.1.3

PUBLIC IP

50.1.1.1
50.1.1.2
50.1.1.3



STEPS

- Configure IP address according to the diagram
- Configure default route towards ISP from R1
- Configure static route from ISP to public IP used for translation
- Configure NAT (static NAT according to the requirement)
- Implementation
- Verify by generating some traffic from LAN to outside servers
show ip nat translations

R-1#sh ip int brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.1.100	YES	manual	up	up
FastEthernet0/1	unassigned	YES	unset	administratively down	down
Serial0/0	100.1.1.1	YES	manual	up	up
Serial0/1	unassigned	YES	unset	administratively down	down

R-1(config)# ip route 0.0.0.0 0.0.0.0 100.1.1.2

ISP#sh ip int brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	200.1.1.100	YES	manual	up	up
FastEthernet0/1	unassigned	YES	unset	administratively down	down
Serial0/0	100.1.1.2	YES	manual	up	up
Serial0/1	unassigned	YES	manual	administratively down	down

```
ISP#conf terminal
ISP(config)# ip route 50.0.0.0 255.0.0.0 100.1.1.1
```

Configuration of static NAT

```
R-1(config)#ip nat inside source static 192.168.1.1 50.1.1.1
R-1(config)#ip nat inside source static 192.168.1.2 50.1.1.2
R-1(config)#ip nat inside source static 192.168.1.3 50.1.1.3
```

Implementation

```
R-1(config)#interface fastEthernet 0/0
R-1(config-if)#ip nat inside
R-1(config-if)#exit
(interface facing towards LAN)
```

```
R-1(config)#interface serial 0/0
R-1(config-if)#ip nat outside
(interface facing towards ISP)
```

Generate Traffic from Inside User PC (192.168.1.1)

```
PC>ipconfig
```

```
IP Address.....: 192.168.1.1
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 192.168.1.100
```

```
PC>ping 200.1.1.1
```

```
Pinging 200.1.1.1 with 32 bytes of data:
Reply from 200.1.1.1: bytes=32 time=12ms TTL=126
Reply from 200.1.1.1: bytes=32 time=12ms TTL=126
Reply from 200.1.1.1: bytes=32 time=10ms TTL=126
Reply from 200.1.1.1: bytes=32 time=20ms TTL=126
```

```
PC>ping 200.1.1.2
```

```
Pinging 200.1.1.2 with 32 bytes of data:
Request timed out.
Reply from 200.1.1.2: bytes=32 time=16ms TTL=126
Reply from 200.1.1.2: bytes=32 time=11ms TTL=126
Reply from 200.1.1.2: bytes=32 time=32ms TTL=126
```

Generate Traffic from Inside User PC (192.168.1.2)

```
PC>ipconfig
```

```
IP Address.....: 192.168.1.2
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 192.168.1.100
```


PC>ping 200.1.1.1

Pinging 200.1.1.1 with 32 bytes of data:

Reply from 200.1.1.1: bytes=32 time=25ms TTL=126

Reply from 200.1.1.1: bytes=32 time=11ms TTL=126

Reply from 200.1.1.1: bytes=32 time=21ms TTL=126

Reply from 200.1.1.1: bytes=32 time=22ms TTL=126

Generate Traffic from Inside User PC (192.168.1.3)

PC>ipconfig

IP Address.....: 192.168.1.3

Subnet Mask.....: 255.255.255.0

Default Gateway.....: 192.168.1.100

PC>ping 200.1.1.1

Pinging 200.1.1.1 with 32 bytes of data:

Reply from 200.1.1.1: bytes=32 time=24ms TTL=126

Reply from 200.1.1.1: bytes=32 time=16ms TTL=126

Reply from 200.1.1.1: bytes=32 time=10ms TTL=126

Reply from 200.1.1.1: bytes=32 time=20ms TTL=126

R-1#sh ip nat translations

Pro	Inside global	Inside local	Outside local	Outside global
icmp	50.1.1.1:21	192.168.1.1:21	200.1.1.2:21	200.1.1.2:21
icmp	50.1.1.1:22	192.168.1.1:22	200.1.1.2:22	200.1.1.2:22
icmp	50.1.1.1:23	192.168.1.1:23	200.1.1.2:23	200.1.1.2:23
icmp	50.1.1.1:24	192.168.1.1:24	200.1.1.2:24	200.1.1.2:24
icmp	50.1.1.2:1	192.168.1.2:1	200.1.1.1:1	200.1.1.1:1
icmp	50.1.1.2:2	192.168.1.2:2	200.1.1.1:2	200.1.1.1:2
icmp	50.1.1.2:3	192.168.1.2:3	200.1.1.1:3	200.1.1.1:3
icmp	50.1.1.2:4	192.168.1.2:4	200.1.1.1:4	200.1.1.1:4
icmp	50.1.1.3:1	192.168.1.3:1	200.1.1.1:1	200.1.1.1:1
icmp	50.1.1.3:2	192.168.1.3:2	200.1.1.1:2	200.1.1.1:2
icmp	50.1.1.3:3	192.168.1.3:3	200.1.1.1:3	200.1.1.1:3
icmp	50.1.1.3:4	192.168.1.3:4	200.1.1.1:4	200.1.1.1:4
---	50.1.1.1	192.168.1.1	---	---
---	50.1.1.2	192.168.1.2	---	---
---	50.1.1.3	192.168.1.3	---	---

To verify generate telnet traffic From Inside User PC's

- 192.168.1.1
- 192.168.1.2
- 192.168.1.3

PC>telnet 100.1.1.2

Trying 100.1.1.2 ...Open

User Access Verification

Password:

R-1#sh ip nat translations

Pro	Inside global	Inside local	Outside local	Outside global
---	50.1.1.1	192.168.1.1	---	---
---	50.1.1.2	192.168.1.2	---	---
---	50.1.1.3	192.168.1.3	---	---
tcp	50.1.1.1:1025	192.168.1.1:1025	100.1.1.2:23	100.1.1.2:23
tcp	50.1.1.2:1025	192.168.1.2:1025	100.1.1.2:23	100.1.1.2:23
tcp	50.1.1.3:1025	192.168.1.3:1025	100.1.1.2:23	100.1.1.2:23



LAB : Dynamic NAT

R-1(config)#access-list <no> permit <source > < Wildcardmask>

R-1(config)#ip nat pool <name> <start Pub-IP> <end-Pub-IP> netmask <subnet-mask>

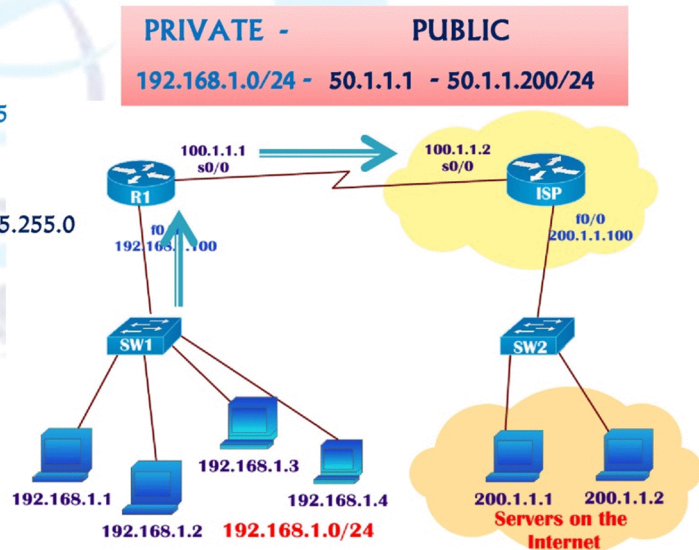
R-1(config)#ip nat inside source list <ACL-no> <poolname>

R-1(config)#access-list 55 permit 192.168.1.0 0.0.0.255

R-1(config)#

ip nat pool CCNA 50.1.1.1 50.1.1.200 netmask 255.255.255.0

R-1(config)#ip nat inside source list 55 pool CCNA



Dynamic NAT - Implementation

Implementation

R-1(config)#interface fastEthernet 0/0

R-1(config-if)#ip nat inside

R-1(config-if)#exit

(Interface facing towards LAN)

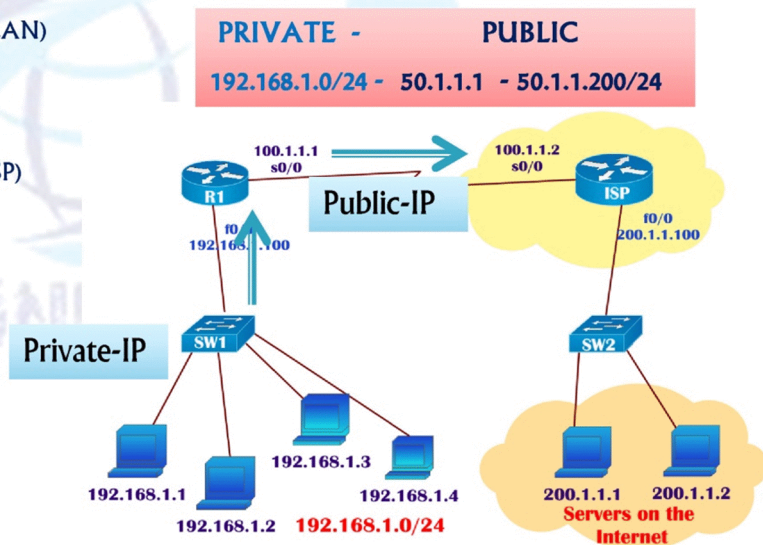
R-1(config)#interface serial 0/0

R-1(config-if)#ip nat outside

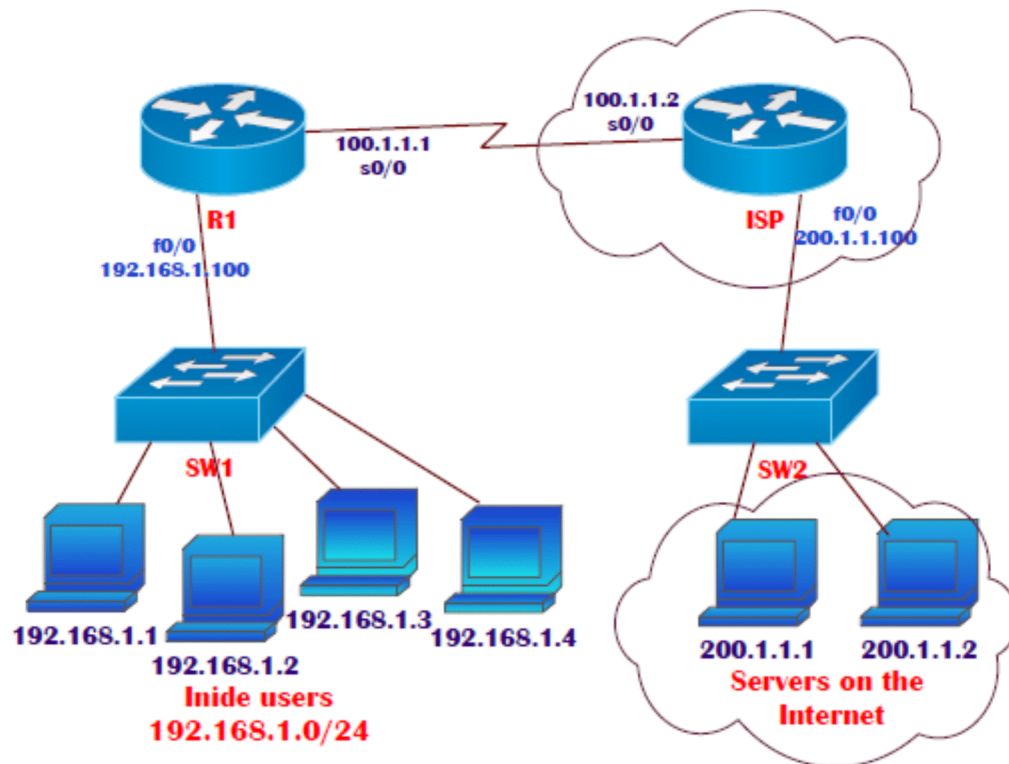
(Interface facing towards ISP)

To verify NAT

R-1#sh ip nat translations



LAB -2 Dynamic NAT



TASK:

- Remove the NAT Configurations done in the previous Lab.
- Configure Dynamic NAT and make sure that the inside LAN users (192.168.1.0/24) get translated to public IP with the range of 50.1.1.1 – 50.1.1.200/24

STEPS:

- Continue with the same pre-configurations in the LAB – 1
- Remove the static NAT configurations.
- Implementation is same as previous lab

R-1#clear ip nat translation *

NOTE:

- Make sure that you clear the translation table before you edit or remove the any NAT configurations

```
R-1(config)# no ip nat inside source static 192.168.1.1 50.1.1.1
```

```
R-1(config)# no ip nat inside source static 192.168.1.2 50.1.1.2
```

```
R-1(config)# no ip nat inside source static 192.168.1.3 50.1.1.3
```

Configuration of DYNAMIC NAT

```
R-1(config)#access-list 55 permit 192.168.1.0 0.0.0.255
R-1(config)#ip nat pool CCNA 50.1.1.1 50.1.1.200 netmask 255.255.255.0
R-1(config)#ip nat inside source list 55 pool CCNA
```

Implementation

```
R-1(config)#interface fastEthernet 0/0
R-1(config-if)#ip nat inside
R-1(config-if)#exit
```

(Interface facing towards LAN)

```
R-1(config)#interface serial 0/0
R-1(config-if)#ip nat outside
```

(Interface facing towards ISP)

Verification:

Generate some telnet traffic from inside LAN devices

- 192.168.1.1
- 192.168.1.2
- 192.168.1.3
- 192.168.1.4

```
PC>telnet 100.1.1.2
Trying 100.1.1.2 ...Open

User Access Verification

Password:
ISP>
```

R-1#sh ip nat translations

Pro	Inside global	Inside local	Outside local	Outside global
tcp	50.1.1.1:1027	192.168.1.1:1027	100.1.1.2:23	100.1.1.2:23
tcp	50.1.1.2:1025	192.168.1.2:1025	100.1.1.2:23	100.1.1.2:23
tcp	50.1.1.3:1025	192.168.1.3:1025	100.1.1.2:23	100.1.1.2:23
tcp	50.1.1.4:1025	192.168.1.4:1025	100.1.1.2:23	100.1.1.2:23

LAB : PAT

R-1(config)#access-list <no> permit <source > <Wildcardmask>

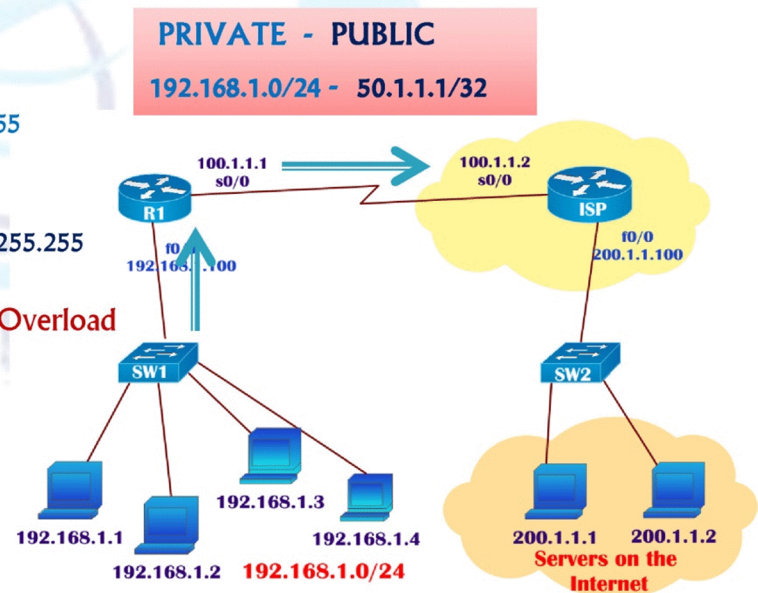
R-1(config)#ip nat pool <name> <start Pub-IP> <end-Pub-IP> netmask <subnet-mask>

R-1(config)#ip nat inside source list <ACL-no> <poolname> Overload

R-1(config)#access-list 55 permit 192.168.1.0 0.0.0.255

R-1(config)#
ip nat pool CCNA 50.1.1.1 50.1.1.1 netmask 255.255.255.255

R-1(config)#ip nat inside source list 55 pool CCNA Overload



PAT- Implementation

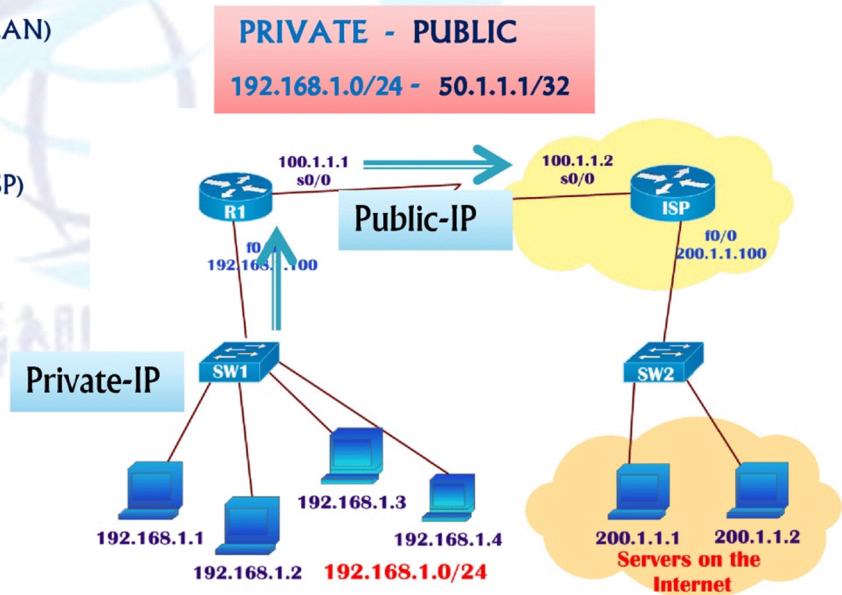
Implementation

```
R-1(config)#interface fastEthernet 0/0
R-1(config-if)#ip nat inside
R-1(config-if)#exit
(interface facing towards LAN)
```

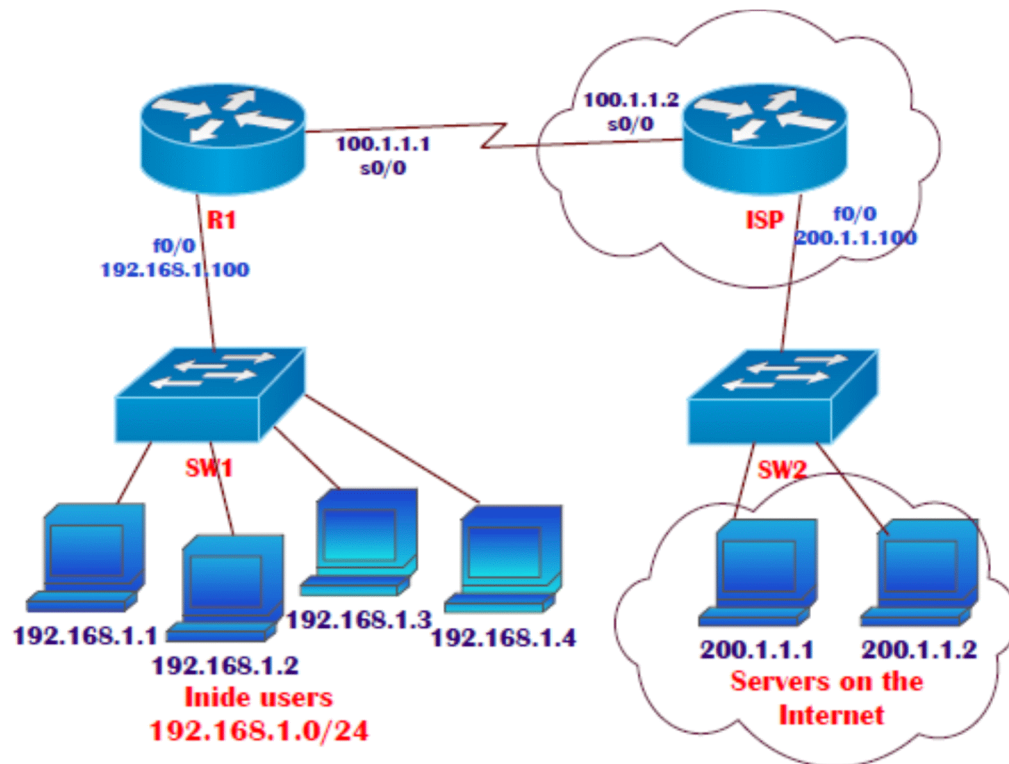
```
R-1(config)#interface serial 0/0
R-1(config-if)#ip nat outside
(Interface facing towards ISP)
```

To verify NAT

```
R-1#sh ip nat translations
```



LAB-3 PORT ADDRESS TRANSLATION



TASK:

- Remove the NAT Configurations done in the previous Lab.
- Configure PAT (Dynamic NAT Overload) and make sure that the inside LAN users (192.168.1.0/24) get translated to single public IP (50.1.1.1/32) given by service provider

STEPS:

- Continue with the same pre-configurations in the LAB – 2
- Remove the dynamic NAT configurations.
- Implementation is same as previous lab

R-1#clear ip nat translation *

NOTE:

- Make sure that you clear the translation table before you edit or remove the any NAT configurations

R-1(config) #no ip nat inside source list 55 pool CCNA

R-1(config) #no ip nat pool CCNA 50.1.1.1 50.1.1.200 netmask 255.255.255.0

R-1(config) #no access-list 55

PAT Configuration

```
R-1(config)#access-list 55 permit 192.168.1.0 0.0.0.255
```

```
R-1(config)#ip nat pool CCNA 50.1.1.1 50.1.1.1 netmask 255.255.255.255
```

```
R-1(config)#ip nat inside source list 55 pool CCNA overload
```

Implementation

```
R-1(config) #interface fastEthernet 0/0
```

```
R-1(config-if) #ip nat inside
```

```
R-1(config-if) #exit
```

(Interface facing towards LAN)

```
R-1(config)#interface serial 0/0
```

```
R-1(config-if)#ip nat outside
```

(Interface facing towards ISP)

Verification:

- Generate some telnet traffic from inside LAN devices (192.168.1.1 //192.168.1.2 //192.168.1.3 //192.168.1.4//)

```
PC>telnet 100.1.1.2
```

```
Trying 100.1.1.2 ...Open
```

```
User Access Verification
```

```
Password:
```

```
ISP>
```

```
R-1#sh ip nat translations
```

Pro	Inside global	Inside local	Outside local	Outside global
tcp	50.1.1.1:1029	192.168.1.1:1029	100.1.1.2:23	100.1.1.2:23
tcp	50.1.1.1:1026	192.168.1.2:1026	100.1.1.2:23	100.1.1.2:23
tcp	50.1.1.1:1024	192.168.1.3:1026	100.1.1.2:23	100.1.1.2:23
tcp	50.1.1.1:1025	192.168.1.4:1026	100.1.1.2:23	100.1.1.2:23

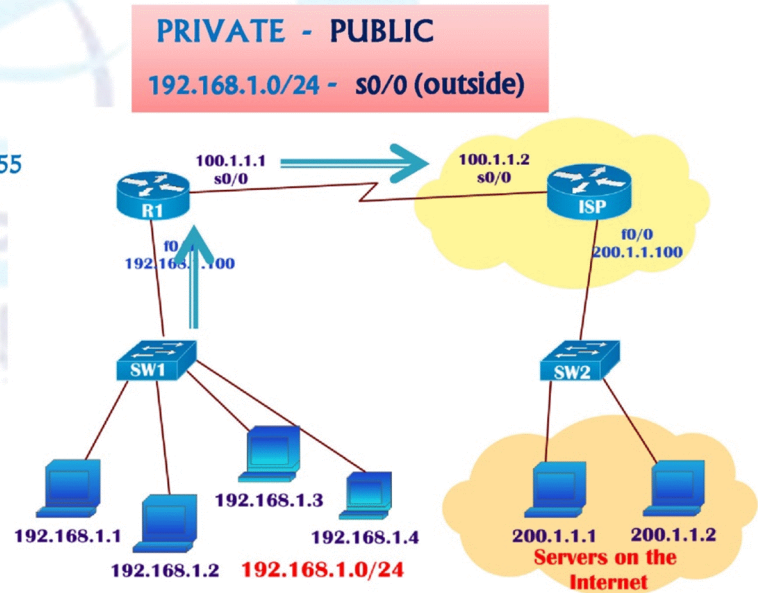
LAB : PAT using exit-interface

R-1(config)#access-list <no> permit <source> <Wildcardmask>

R-1(config)#ip nat inside source list <ACL-no> <poolname> Overload

R-1(config)#access-list 55 permit 192.168.1.0 0.0.0.255

R-1(config)#
ip nat inside source list 55 interface s0/0 Overload



PAT - Implementation

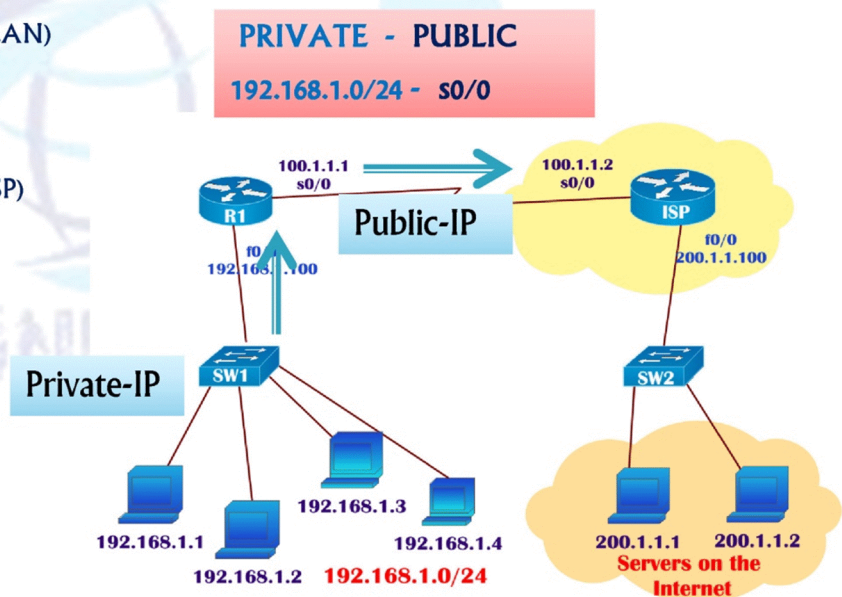
Implementation

```
R-1(config)#interface fastEthernet 0/0
R-1(config-if)#ip nat inside
R-1(config-if)#exit
(interface facing towards LAN)
```

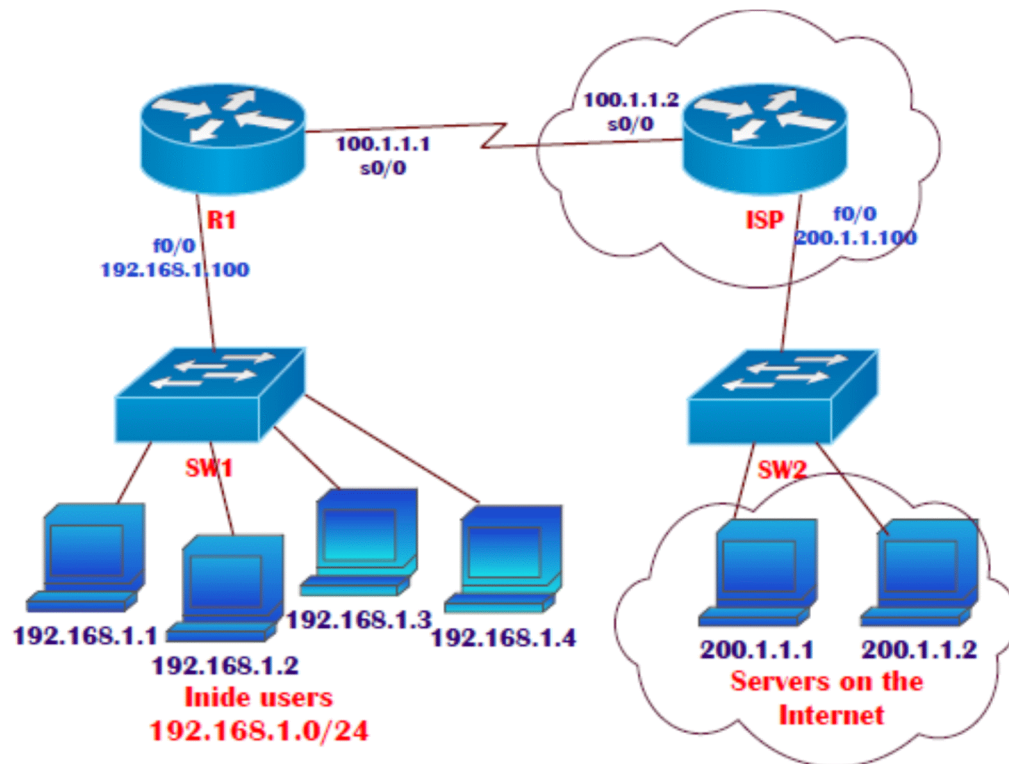
```
R-1(config)#interface serial 0/0
R-1(config-if)#ip nat outside
(Interface facing towards ISP)
```

To verify NAT

```
R-1#sh ip nat translations
```



LAB-4 PORT ADDRESS TRANSLATION using Exit Interface



TASK:

- Remove the NAT Configurations done in the previous Lab.
- Configure PAT (Dynamic NAT Overload) and make sure that the inside LAN users (192.168.1.0/24) get translated to single public IP on the **outside interface (100.1.1.1)** given by service provider.

STEPS:

- Continue with the same pre-configurations in the LAB – 3
- Remove the PAT configurations.
- Implementation is same as previous lab

```
R-1#clear ip nat translation *
```

NOTE:

- Make sure that you clear the translation table before you edit or remove the any NAT configurations

```
R-1(config)#no ip nat inside source list 55 pool CCNA overload
```

```
R-1(config)#no ip nat pool CCNA 50.1.1.1 50.1.1.1 netmask 255.255.255.248
```

```
R-1(config)#no access-list 55
```

PAT Configuration


```
R-1(config)#access-list 55 permit 192.168.1.0 0.0.0.255
```

```
R-1(config)#ip nat inside source list 55 interface serial 0/0 overload
```

Implementation

```
R-1(config)#interface fastEthernet 0/0
```

```
R-1(config-if)#ip nat inside
```

```
R-1(config-if)#exit
```

(interface facing towards LAN)

```
R-1(config)#interface serial 0/0
```

```
R-1(config-if)#ip nat outside
```

(Interface facing towards ISP)

Verification:

- Generate some telnet traffic from inside LAN devices (192.168.1.1 //192.168.1.2 //192.168.1.3 //192.168.1.4//)

```
PC>telnet 100.1.1.2  
Trying 100.1.1.2 ...Open
```

User Access Verification

```
Password:  
ISP>
```

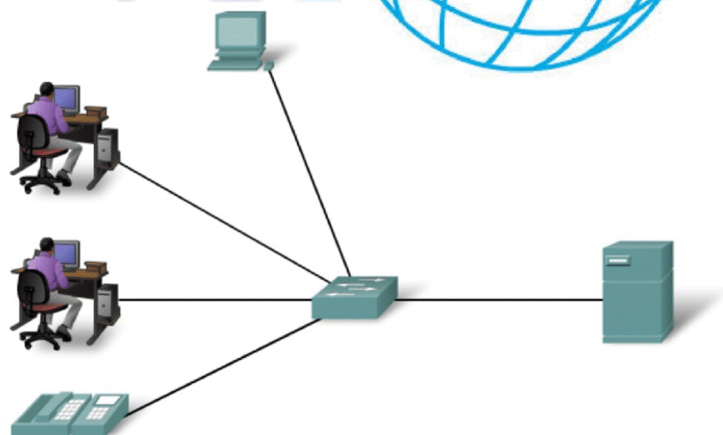
```
R-1#sh ip nat translations
```

Pro	Inside global	Inside local	Outside local	Outside global
tcp	100.1.1.1:1029	192.168.1.1:1029	100.1.1.2:23	100.1.1.2:23
tcp	100.1.1.1:1026	192.168.1.2:1026	100.1.1.2:23	100.1.1.2:23
tcp	100.1.1.1:1024	192.168.1.3:1026	100.1.1.2:23	100.1.1.2:23
tcp	100.1.1.1:1025	192.168.1.4:1026	100.1.1.2:23	100.1.1.2:23

IPV6

What is TCP/IP?

- ▶ TCP/IP is a standard protocol used between computers and network devices for communication.
- ▶ Internet work based on TCP/IP

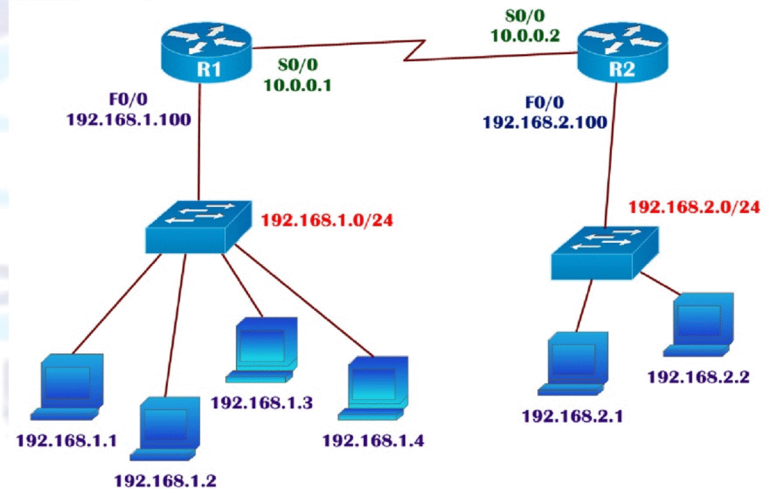
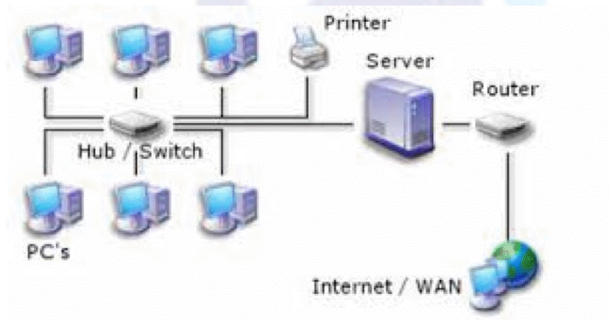


TCP/IP addressing

- ▶ IP Address is Logical Address given to each and every device in the network.
- ▶ IP address used to identify specific device in the network.

Two Versions of IP:

- IP version 4 (32 bit)
- IP version 6 (128 bit)



Techniques to reduce address shortage in IPv4

- Subnetting
- Network Address Translation (NAT)

IPv6

- ▶ IPv6 next version of addressing using TCP/IP protocols
- ▶ Introduced to overcome the shortage of address in IPv4
- ▶ Supported large address space (128 bit).

IPV6 Addressing

- ▶ 128 bit address
- ▶ Hexadecimal format

64 bit Global Prefix				64 bit Interface ID			
2001:	0db8:	0000:	0000:	1234:	0000:	0000:	3c4d

2001:	Each portion = 16 bits
	8 portions = 128 bits
	Each digit = 4 bits

IPV6 Addressing

2001:	0db8:	0000:	0000:	1234:	0000:	0000:	3c4d
-------	-------	-------	-------	-------	-------	-------	------

2001:	db8 :	0 :	0 :	1234 :	0 :	0 :	3c4d
-------	-------	-----	-----	--------	-----	-----	------

2001:	db8	::	1234	::	3c4d
-------	-----	----	------	----	------



2001:	db8	::	1234	0 :	0 :	3c4d
-------	-----	----	------	-----	-----	------



IPV6 address Types

- ▶ Unicast
- ▶ Multicast
- ▶ Any cast

Unicast Address



1) Global unicast

- like public IP (routable)
- starts with 2000::/3 (the first three bits 001) assigned by IANA
- Starts with 2 or 3

2) unique local

- like private ip (routable)
- FC00::/7
- Starts with either FC or FD in the first two numbers.
- Not recognized on internet (with the same organization LAN/WAN)

Unicast Address

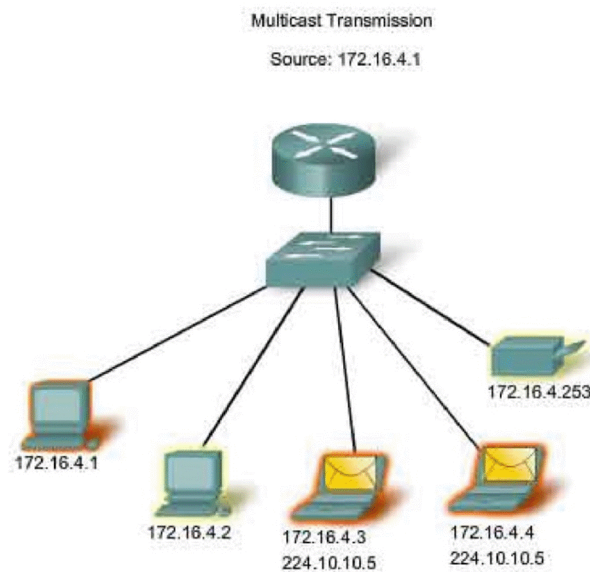
3)link local

- default IPV6 address on every ipv6 enabled interface(non routable) FE80::/10
- Routers do not forward packets with link-local addresses.



Multicast

- In IPV6 multicast address will be starting with FF (FF00::/8)

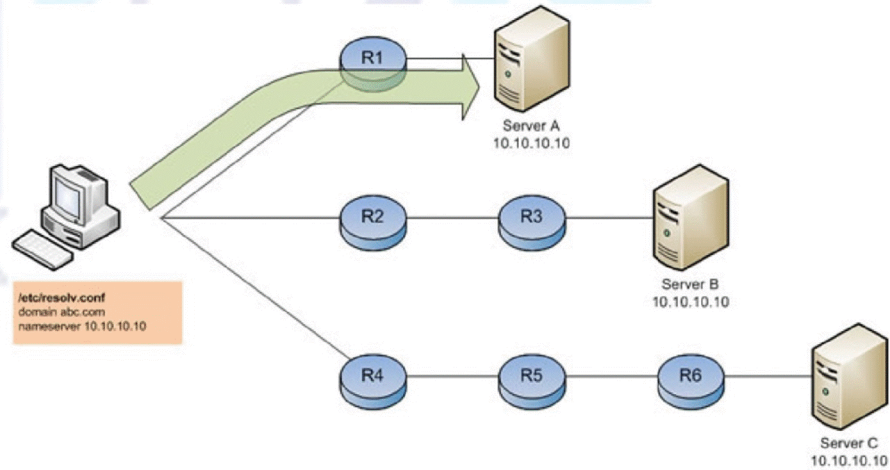


Any cast

- similar to multicast , identify multiple interfaces but sends to only one whichever it finds first.
- unique local and Global unicast addresses can be used as anycast.

Device(config)# interface f0/0

Device(config-if)# IPv6 address ipv6-prefix/prefix-length anycast

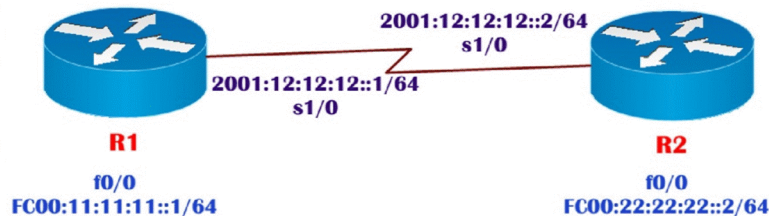


Assigning the IPV6 address on cisco routers

R-1(config)#interface s1/0

R-1(config-if)#ipv6 address 2001:12:12:12::1/64

R-1(config-if)#no shutdown



R-1(config)#interface fastethernet 0/0

R-1(config-if)#ipv6 address fc00:11:11:11::1/64

R-1(config-if)#no shutdown

IPv6 ROUTING

IPv6 uses the same types of routing protocols as IPv4 with some slight modifications to account for specific requirements of IPv6.

IPv6 ROUTING TYPES

- Static/ default
- RIPng
- OSPFv3
- EIGRP for IPv6



IPv6 routing has to be enabled before using any routing process as by default IPv6 routing is disabled for IPv6.

To enable ipv6 routing on both routers

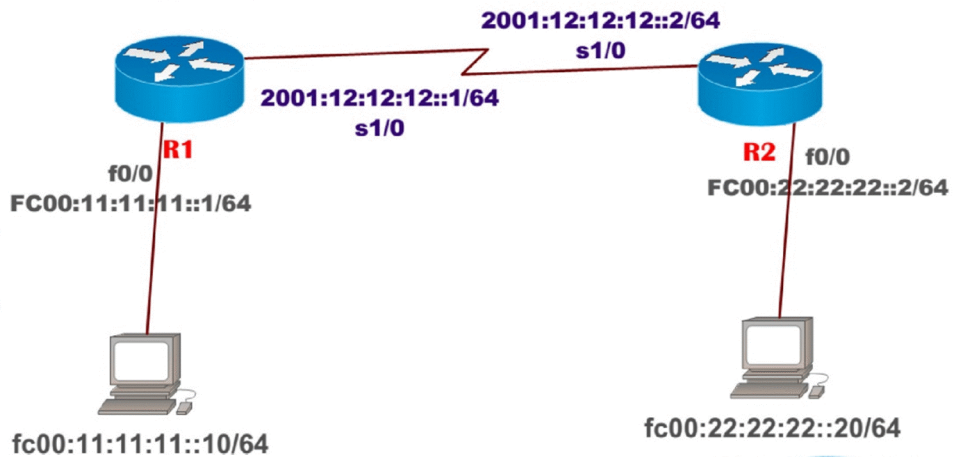
Rx(config)#**ipv6 unicast-routing**

Static Routing

Syntax for writing static and default routing is similar in IPV6 when compared with IPV4

R-1(config)#**ipv6 route** **fc00:22:22:22::/64** **2001:12:12:12::2**

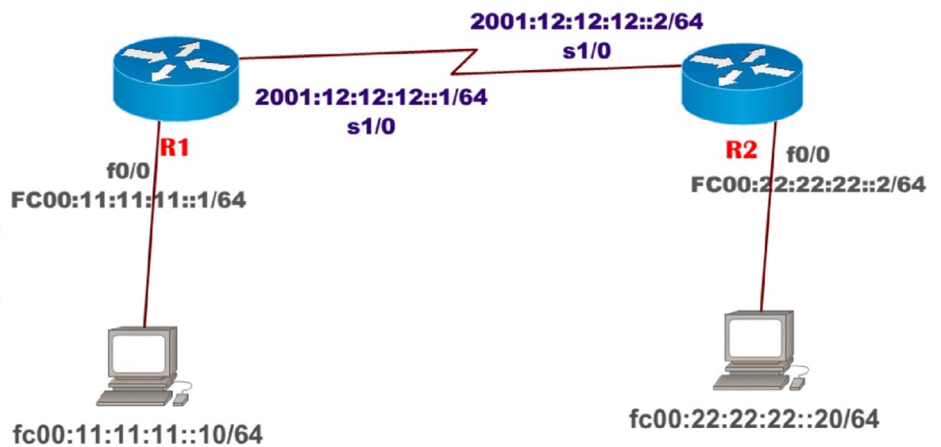
R-2(config)#**ipv6 route** **fc00:11:11:11::/64** **2001:12:12:12::1**



Default Routing

R-1(config)#**ipv6 route** **0::/0** **2001:12:12:12::2**

R-2(config)#**ipv6 route** **0::/0** **2001:12:12:12::1**



IPv6 Dynamic Routing Protocols

Dynamic Routing in IPv6 is unchanged from IPv4

- ▶ RIPng
- ▶ Cisco EIGRP for IPv6
- ▶ OSPFv3

RIPng

R-1(config)#**ipv6 router rip CCIE**

R-1(config-rtr)#**exit**

R-1(config)#**int f0/0**

R-1(config-if)#**ipv6 rip CCIE enable**

R-1(config-if)#**exit**

R-1(config)#**int s1/0**

R-1(config-if)#**ipv6 rip CCIE enable**

R-1(config-if)#**end**

R-2(config)#**ipv6 router rip CCIE**

R-2(config-rtr)#**exit**

R-2(config)#**int f0/0**

R-2(config-if)#**ipv6 rip CCIE enable**

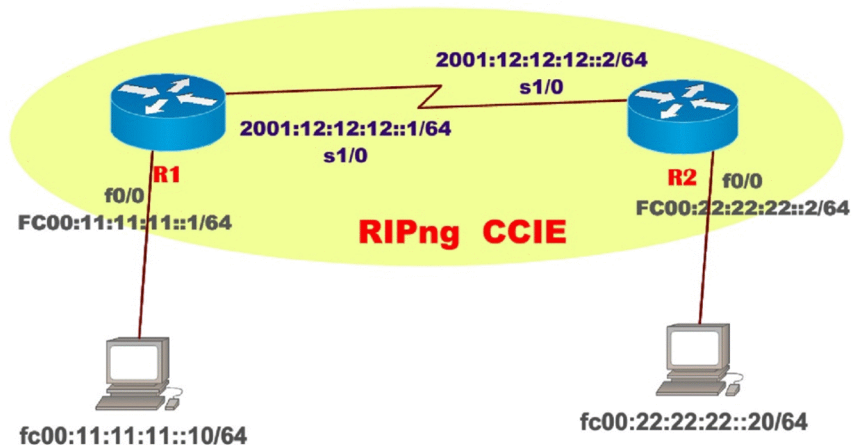
R-2(config-if)#**exit**

R-2(config)#**int s1/0**

R-2(config-if)#**ipv6 rip CCIE enable**

R-2(config-if)#**end**

Process ID must be same on both routers to exchange routes



RIPng Verification

R-1#sh ipv6 route

```
C 2001:12:12:12::/64 [0/0]
  via ::, Serial0/0/0
L 2001:12:12:12::1/128 [0/0]
  via ::, Serial0/0/0
C FC00:11:11:11::/64 [0/0]
  via ::, FastEthernet0/0
L FC00:11:11:11::1/128 [0/0]
  via ::, FastEthernet0/0
R FC00:22:22:22::/64 [120/1]
  via FE80::210:11FF:FEAB:101, Serial0/0/0
L FF00::/8 [0/0]
  via ::, Null0
```

R-1#ping fc00:22:22:22::2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to fc00:22:22:22::2, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 3/4/5 ms

R-1#sh ipv6 protocols

IPv6 Routing Protocol is "connected"

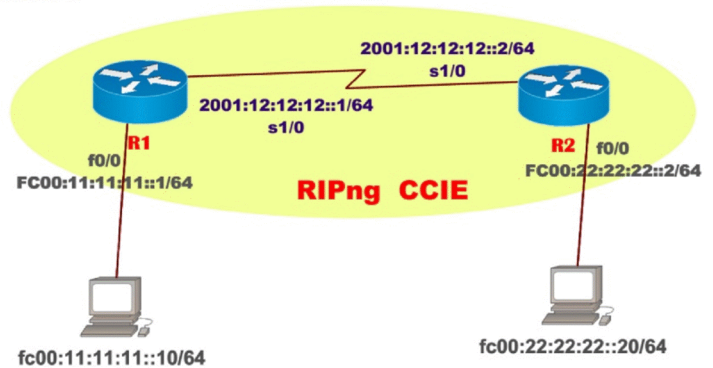
IPv6 Routing Protocol is "static"

IPv6 Routing Protocol is "rip CCIE"

Interfaces:

FastEthernet0/0

Serial0/0/0



OSPFv3

R-1(config)#ipv6 router ospf 1

R-1(config-rtr)#router-id 11.1.1.1

R-1(config-rtr)#exit

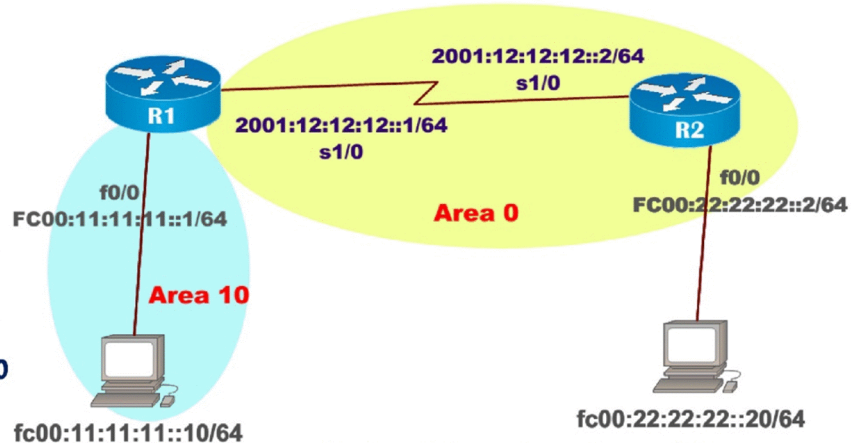
R-1(config)#int s1/0

R-1(config-if)#ipv6 ospf 1 area 0

R-1(config-if)#int f0/0

R-1(config-if)#ipv6 ospf 1 area 10

R-1(config-if)#exit



R-2(config)#ipv6 router ospf 1

R-2(config-rtr)#router-id 22.2.2.2

R-2(config-rtr)#exit

R-2(config)#int s1/0

R-2(config-if)#ipv6 ospf 1 are 0

R-2(config-if)#int f0/0

R-2(config-if)#ipv6 ospf 1 are 0

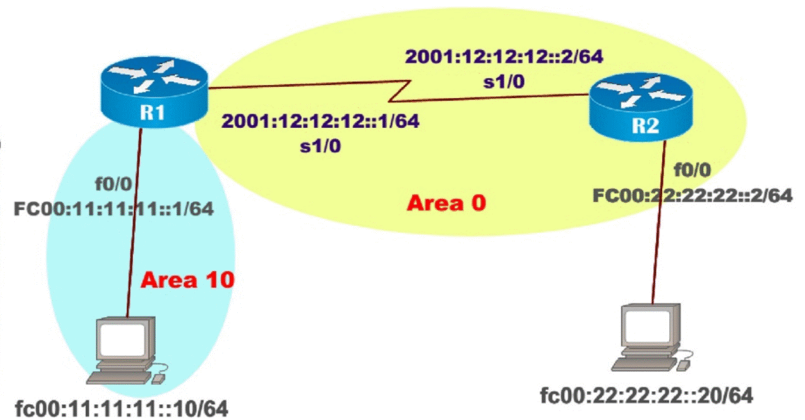
OSPFv3 Verification

R-1#sh ipv6 route ospf

IPv6 Routing Table - 6 entries

○ FC00:22:22:22::/64 [110/64]

via FE80::210:11FF:FEAB:101, Serial0/0/0



R-1#sh ipv6 ospf neighbor

Neighbor ID	Pri	State	Dead Time	Interface ID	Interface
22.2.2.2	0	FULL/ -	00:00:30	3	Serial0/0/0

R-1#ping fc00:22:22:22::2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to fc00:22:22:22::2, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 2/4/7 ms

EIGRPv6

R1(config)#ipv6 router eigrp 100

R-1(config-rtr)#eigrp router-id 11.1.1.1

R-1(config-rtr)#no shutdown

R-1(config-rtr)#exit

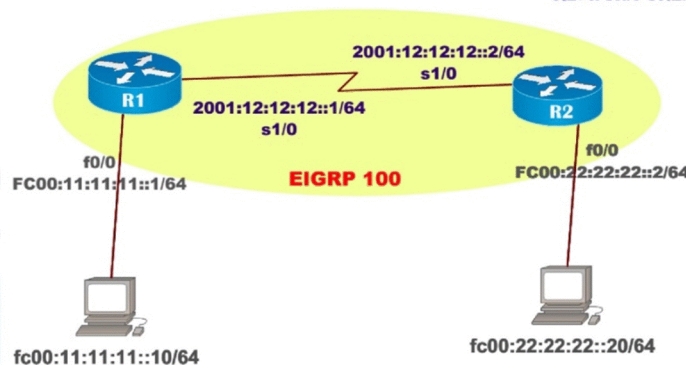
R-1(config)#interface s1/0

R-1(config-if)#ipv6 eigrp 100

R-1(config-if)#int f0/0

R-1(config-if)#ipv6 eigrp 100

R-1(config-if)#end



R2(config)#ipv6 router eigrp 100

R-2config-rtr)#router-id 22.2.2.2

R-2(config-rtr)#no shutdown

R-2config-rtr)#exit

R-2(config)#int s1/0

R-2(config-if)#ipv6 eigrp 100

R-2(config-if)#int f0/0

R-2(config-if)#ipv6 eigrp 100

EIGRPv6 verification

R-1#sh ipv6 route eigrp

```
D  FC00:22:22:22::/64 [90/2172416]
  via FE80::210:11FF:FEAB:101, Serial0/0/0
```

R-1#sh ipv6 eigrp neighbors

IPv6-EIGRP neighbors for process 100

H	Address	Interface	Hold (sec)	Uptime (ms)	SRTT Cnt	RTO Num	Q	Seq
0	FE80::210:11FF:FEAB:101	Se0/0/0	12	00:00:20	40	1000	0	4

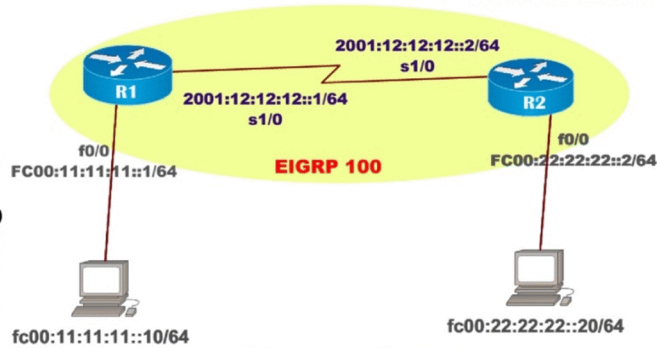
R-1#ping fc00:22:22:22::2

Type escape sequence to abort.

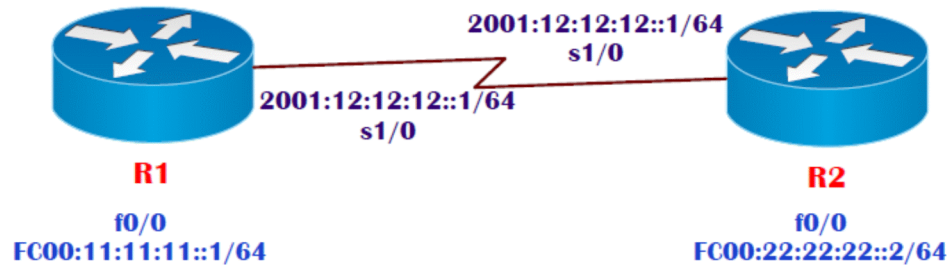
Sending 5, 100-byte ICMP Echos to fc00:22:22:22::2, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 2/4/9 ms



LAB: Basic configuration of Ipv6 & IPV6 Routing



TASK

- Configure basic Ipv6 Addresses as per the diagram

```
Router (config) #hostname R-1
```

```
R-1(config) #interface fastEthernet 0/0
```

```
R-1(config-if) #ipv6 address fc00:11:11:11::1/64
```

```
R-1(config-if) #no shutdown
```

```
R-1(config-if) #exit
```

```
R-1(config)#interface s1/0
```

```
R-1(config-if)#ipv6 address 2001:12:12:12::1/64
```

```
R-1(config-if)#no shutdown
```

```
R-1(config-if)#end
```

```
Router (config)#hostname R-2
```

```
R-2(config)#interface fastEthernet 0/0
```

```
R-2(config-if)#ipv6 address fc00:22:22:22::2/64
```

```
R-2(config-if)#no shutdown
```

```
R-2(config-if)#exit
```

```
R-2(config)#interface serial 1/0
```

```
R-2(config-if)#ipv6 address 2001:12:12:12::2/64
```

```
R-2(config-if)#no shutdown
```

```
R-2(config-if)#clock rate 64000
```

```
R-2(config-if)#end
```

```
R-2#show ipv6 int brief
```

```
FastEthernet0/0      [up/up]
```

```
FE80::2E0:F9FF:FEC3:3B01
```

```
FC00:22:22:22::2
```

```
FastEthernet0/1      [administratively down/down]
```

```
Serial 1/0[up/up]
```

```
FE80::210:11FF:FEAB:101
```

```
2001:12:12:12::2
```

```
Serial 1/1[administratively down/down]
```

```
Vlan1                [administratively down/down]
```

R-2#ping 2001:12:12:12::1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:12:12:12::1, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 2/6/19 ms

R-2#ping 2001:12:12:12::2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:12:12:12::2, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 8/11/16 ms

TASK

- Configure R1 and R2 so that they can communicate each other. Use static routing

R-1(config)#ipv6 route fc00:22:22:22::/64 2001:12:12:12::2

R-2(config)#ipv6 route fc00:11:11:11::/64 s1/0

R-1#sh ipv6 route

IPv6 Routing Table - 6 entries

C 2001:12:12:12::/64 [0/0]

via ::, Serial0/0/0

L 2001:12:12:12::1/128 [0/0]

via ::, Serial0/0/0

C FC00:11:11:11::/64 [0/0]

via ::, FastEthernet0/0

L FC00:11:11:11::1/128 [0/0]

via ::, FastEthernet0/0

S FC00:22:22:22::/64 [1/0]

via 2001:12:12:12::2

L FF00::/8 [0/0]

via ::, Null0

R-1#ping fc00:22:22:22::2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to fc00:22:22:22::2, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 3/4/6 ms

R-1#trace fc00:22:22:22::2

Type escape sequence to abort.

Tracing the route to fc00:22:22:22::2

1 2001:12:12:12::24 msec 4 msec 6 msec

R-2#sh ipv6 route

IPv6 Routing Table - 6 entries

```
C 2001:12:12:12::/64 [0/0]
  via ::, Serial0/0/0
L 2001:12:12:12::2/128 [0/0]
  via ::, Serial0/0/0
S FC00:11:11:11::/64 [1/0]
  via ::, Serial0/0/0
C FC00:22:22:22::/64 [0/0]
  via ::, FastEthernet0/0
L FC00:22:22:22::2/128 [0/0]
  via ::, FastEthernet0/0
L FF00::/8 [0/0]
  via ::, Null0
```

R-2#ping fc00:11:11:11::1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to fc00:11:11:11::1, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 2/3/5 ms

R-2#trace fc00:11:11:11::1

Type escape sequence to abort.

Tracing the route to fc00:11:11:11::1

```
1 2001:12:12:12::14 msec 5 msec 2 msec
```

TASK

- Remove the static routing on R1 R2 configured in the previous task.
- configure R1, R2 so that they can communicate each other using default routing

R-1(config)#no ipv6 route fc00:22:22:22::/64 2001:12:12:12::2

R-2(config)#no ipv6 route fc00:11:11:11::1/64 s1/0

R-1(config)#ipv6 route 0::/0 2001:12:12:12::2

R-2(config)#ipv6 route 0::/0 s1/0

R-1#sh ipv6 route

IPv6 Routing Table - 6 entries

```
S ::/0 [1/0]
  via 2001:12:12:12::2
C 2001:12:12:12::/64 [0/0]
```

```
via ::, Serial0/0/0
L 2001:12:12:12::1/128 [0/0]
via ::, Serial0/0/0
C FC00:11:11:11::/64 [0/0]
via ::, FastEthernet0/0
L FC00:11:11:11::1/128 [0/0]
via ::, FastEthernet0/0
L FF00::/8 [0/0]
via ::, Null0
```

R-1#ping fc00:22:22:22::2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to fc00:22:22:22::2, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 3/3/5 ms

R-2#sh ipv6 route

IPv6 Routing Table - 6 entries

S ::/0 [1/0]

via ::, Serial0/0/0

C 2001:12:12:12::/64 [0/0]

via ::, Serial0/0/0

L 2001:12:12:12::2/128 [0/0]

via ::, Serial0/0/0

C FC00:22:22:22::/64 [0/0]

via ::, FastEthernet0/0

L FC00:22:22:22::2/128 [0/0]

via ::, FastEthernet0/0

L FF00::/8 [0/0]

via ::, Null0

R-2#ping fc00:11:11:11::1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to fc00:11:11:11::1, timeout is 2 seconds:

!!!!

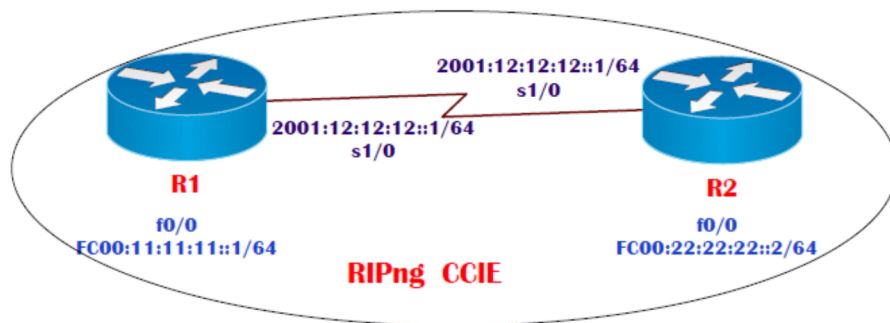
Success rate is 100 percent (5/5), round-trip min/avg/max = 3/3/5 ms

TASK

- Remove the default routing on R1, R2
- Configure R1 R2 so that they can communicate each other. use RIPng routing protocol .

```
R-1(config)#no ipv6 route 0::/0 2001:12:12:12::2
```

```
R-2(config)#no ipv6 route 0::/0 s1/0
```



IPv6 routing has to be enabled before using any dynamic routing protocols in IPv6.

Two steps in Dynamic protocols in IPV6 :

- 1) Configure protocol
- 2) Enable protocol in interface for advertisement of networks

To enable ipv6 routing on both routers

```
Rx(config)#ipv6 unicast-routing
```

To Configure RIPNG

```
R-1(config)#ipv6 router rip CCIE
```

```
R-1(config-rtr)#exit
```

The name used for process ID should be same in order to exchange the routes

```
R-1(config)#int f0/0
```

```
R-1(config-if)#ipv6 rip CCIE enable
```

```
R-1(config-if)#exit
```

```
R-1(config)#int s1/0
```

```
R-1(config-if)#ipv6 rip CCIE enable
```

```
R-1(config-if)#end
```

```
R-1#sh ipv6 protocols
```

```
IPv6 Routing Protocol is "connected"
```

```
IPv6 Routing Protocol is "static"
```


IPv6 Routing Protocol is "rip CCIE"

Interfaces:

FastEthernet0/0

Serial0/0/0

R-2(config)#ipv6 router rip CCIE

R-2(config-rtr)#exit

R-2(config)#int f0/0

R-2(config-if)#ipv6 rip CCIE enable

R-2(config-if)#int s1/0

R-2(config-if)#ipv6 rip CCIE enable

R-2(config-if)#end

R-2#sh ipv6 protocols

IPv6 Routing Protocol is "connected"

IPv6 Routing Protocol is "static"

IPv6 Routing Protocol is "rip CCIE"

Interfaces:

FastEthernet0/0

Serial0/0/0

R-2#sh ipv6 route

IPv6 Routing Table - 6 entries

C 2001:12:12:12::/64 [0/0]

via ::, Serial0/0/0

L 2001:12:12:12::2/128 [0/0]

via ::, Serial0/0/0

R FC00:11:11:11::/64 [120/1]

via FE80::290:2BFF:FEE9:4201, Serial0/0/0

C FC00:22:22:22::/64 [0/0]

via ::, FastEthernet0/0

L FC00:22:22:22::2/128 [0/0]

via ::, FastEthernet0/0

L FF00::/8 [0/0]

via ::, Null0

R-1#sh ipv6 route

IPv6 Routing Table - 6 entries

Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP

U - Per-user Static route, M - MIPv6

I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary

O - OSPF intra, OI - OSPF inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2

ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2

D - EIGRP, EX - EIGRP external
 C 2001:12:12:12::/64 [0/0]
 via ::, Serial0/0/0
 L 2001:12:12:12::1/128 [0/0]
 via ::, Serial0/0/0
 C FC00:11:11:11::/64 [0/0]
 via ::, FastEthernet0/0
 L FC00:11:11:11::1/128 [0/0]
 via ::, FastEthernet0/0
 R FC00:22:22:22::/64 [120/1]
 via FE80::210:11FF:FEAB:101, Serial0/0/0
 L FF00::/8 [0/0]
 via ::, Null0

R-1#ping fc00:22:22:22::2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to fc00:22:22:22::2, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 3/4/5 ms

R-2#ping fc00:11:11:11::1

Type escape sequence to abort.

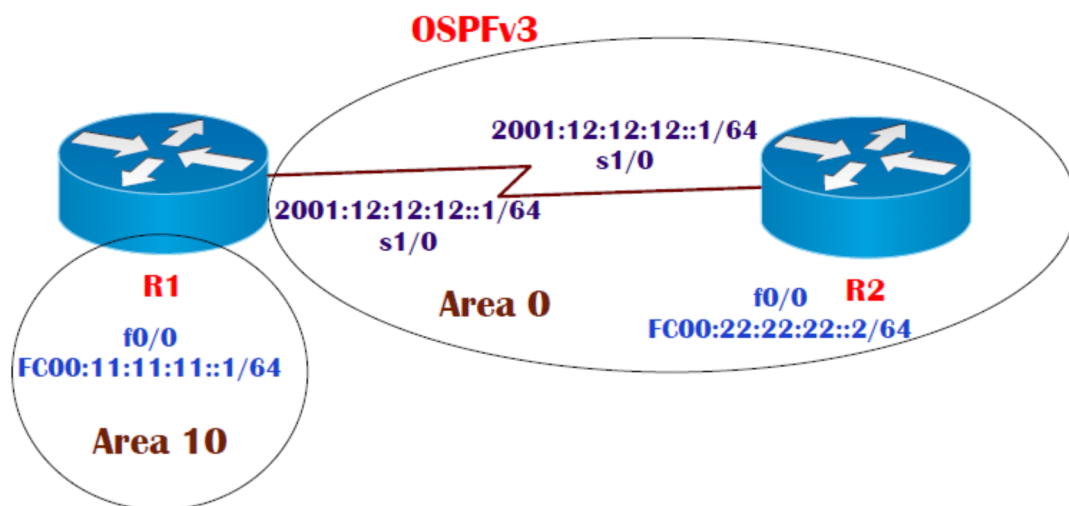
Sending 5, 100-byte ICMP Echos to fc00:11:11:11::1, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 3/3/5 ms

TASK

- Remove RIPv3 routing protocol on R1, R2 configured in the previous task.
- Configure R1 R2 so that they can communicate each other. Use OSPFv3 routing protocol using multiple areas as per the diagram.



On Both routers

```
R-x(config)#no ipv6 router rip CCIE
```

```
R-1(config)#exit
```

OSPFv3 Router-ID has to be in IPV4 format. Router ID is used to identify each router Router ID

1. preference is for manual Router ID command in IPV4 format
2. if not manually configured , then preference is given to logical interface (loopback interface if configured) in IPV4 format
3. if there is no loopback interfaces configured then Highest IP address on Active Physical Interface in IPV4 format

```
R-1(config)#ipv6 router ospf 1
```

```
%OSPFv3-4-NORTRID: OSPFv3 process 1 could not pick a router-id, please configure manually
```

```
R-1(config-rtr)#router-id 11.1.1.1
```

```
R-1(config-rtr)#exit
```

```
R-1(config)#int s1/0
```

```
R-1(config-if)#ipv6 ospf 1 area 0
```

```
R-1(config-if)#int f0/0
```

```
R-1(config-if)#ipv6 ospf 1 area 10
```

```
R-1(config-if)#exit
```

```
R-2(config)#ipv6 router ospf 1
```

```
R-2(config-rtr)#router-id 22.2.2.2
```

```
R-2(config)#int s1/0
```

```
R-2(config-if)#ipv6 ospf 1 area 0
```

```
R-2(config-if)#int f0/0
```

```
R-2(config-if)#ipv6 ospf 1 area 0
```

```
R-2(config-if)#end
```

```
R-1#sh ipv6 ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Interface ID	Interface
22.2.2.2	0	FULL/ -	00:00:30	3	Serial0/0/0

```
R-1#sh ipv6 route ospf
```

```
IPv6 Routing Table - 6 entries
```

```
O FC00:22:22:22::/64 [110/64]
```

```
via FE80::210:11FF:FEAB:101, Serial0/0/0
```

```
R-1#ping fc00:22:22:22::2
```

```
Type escape sequence to abort.
```

```
Sending 5, 100-byte ICMP Echos to fc00:22:22:22::2, timeout is 2 seconds:
```

```
!!!!
```

```
Success rate is 100 percent (5/5), round-trip min/avg/max = 2/4/7 ms
```


R-2#sh ipv ospf neighbor

Neighbor ID	Pri	State	Dead Time	Interface ID	Interface
11.1.1.1	0	FULL/	-	00:00:34 3	Serial0/0/0

R-2#sh ipv route ospf

IPv6 Routing Table - 6 entries

Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP

U - Per-user Static route, M - MIPv6

I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary

O - OSPF intra, OI - OSPF inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2

ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2

D - EIGRP, EX - EIGRP external

OI FC00:11:11:11::/64 [110/64]

via FE80::290:2BFF:FEE9:4201, Serial0/0/0

R-2#ping fc00:11:11:11:: 1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to fc00:11:11:11::1, timeout is 2 seconds:

!!!!

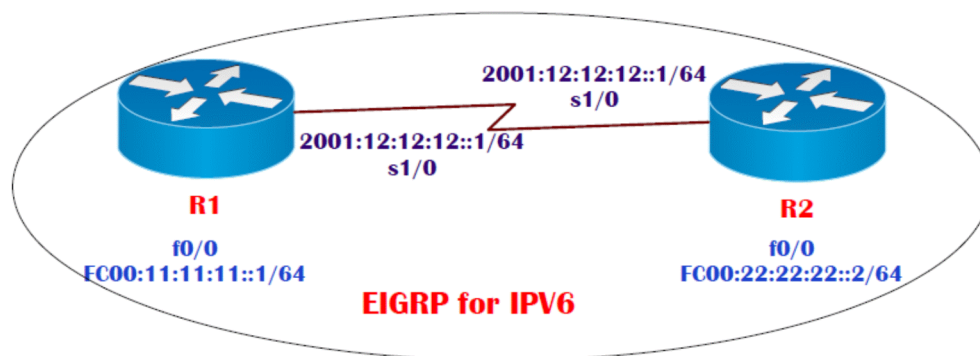
Success rate is 100 percent (5/5), round-trip min/avg/max = 3/6/13 ms

TASK

- Remove OSPFv3 routing protocol on R1, R2 configured in the previous task.
- Configure R1 R2 so that they can communicate each other.
- use EIGRP for IPV6 routing protocol as per the diagram

On both routers

R-x(config)#no ipv6 router ospf 1



R1(config)#ipv6 router eigrp 100

R1(config-rtr)#no shutdown

R1(config-rtr)#router-id 11.1.1.1

R1(config-rtr)#exit

```

R-1(config)#interface s1/0
R-1(config-if)#ipv6 eigrp 100
R-1(config-if)#int f0/0
R-1(config-if)#ipv6 eigrp 100
R-1(config-if)#end

```

No shutdown command is mandatory and router-id is optional in EIGRP

```

R2(config)#ipv6 router eigrp 100
R-2(config-rtr)#no shutdown
R-2config-rtr)#router-id 22.2.2.2

```

```

R-2(config)#int s1/0
R-2(config-if)#ipv6 eigrp 100

```

```

R-2(config-if)#int f0/0
R-2(config-if)#ipv6 eigrp 100
R-2(config-if)#end

```

```

R-1#sh ipv6 eigrp neighbors
IPv6-EIGRP neighbors for process 100
  H  Address          Interface    Hold Uptime   SRTT  RTO  Q  Seq
    (sec)          (ms)      Cnt  Num
  O  FE80::210:11FF:FEAB:101Se0/0/0    12  00:00:20  40   1000  0   4

```

```

R-1#sh ipv6 route
IPv6 Routing Table - 6 entries
C  2001:12:12:12::/64 [0/0]
  via ::, Serial0/0/0
L  2001:12:12:12::1/128 [0/0]
  via ::, Serial0/0/0
C  FC00:11:11:11::/64 [0/0]
  via ::, FastEthernet0/0
L  FC00:11:11:11::1/128 [0/0]
  via ::, FastEthernet0/0
D  FC00:22:22:22::/64 [90/2172416]
  via FE80::210:11FF:FEAB:101, Serial0/0/0
L  FF00::/8 [0/0]
  via ::, Null0

```

```

R-2#sh ipv6 route
IPv6 Routing Table - 6 entries
C  2001:12:12:12::/64 [0/0]
  via ::, Serial0/0/0
L  2001:12:12:12::2/128 [0/0]
  via ::, Serial0/0/0

```

D FC00:11:11:11::/64 [90/2172416]
via FE80::290:2BFF:FEE9:4201, Serial0/0/0
C FC00:22:22:22::/64 [0/0]
via ::, FastEthernet0/0
L FC00:22:22:22::2/128 [0/0]
via ::, FastEthernet0/0
L FF00::/8 [0/0]
via ::, Null0

R-2#ping fc00:11:11:11::1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to fc00:11:11:11::1, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 3/6/15 ms

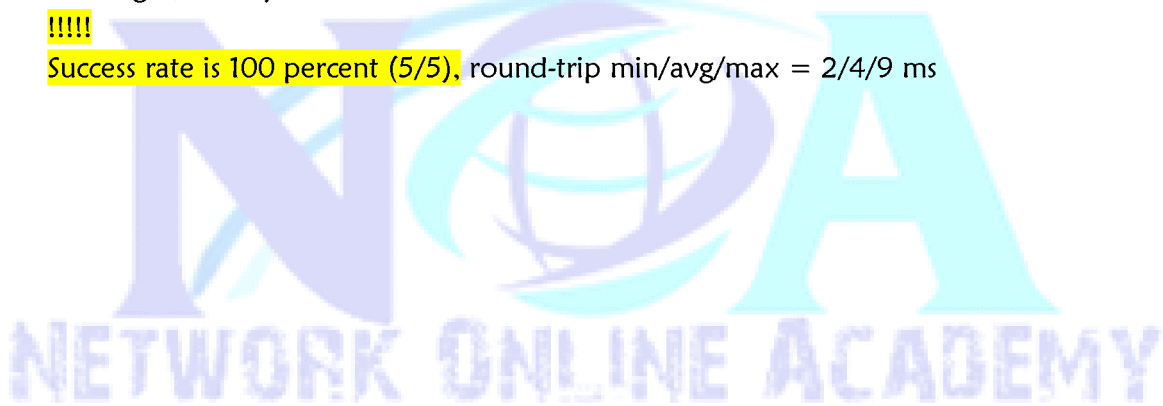
R-1#ping fc00:22:22:22::2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to fc00:22:22:22::2, timeout is 2 seconds:

!!!!

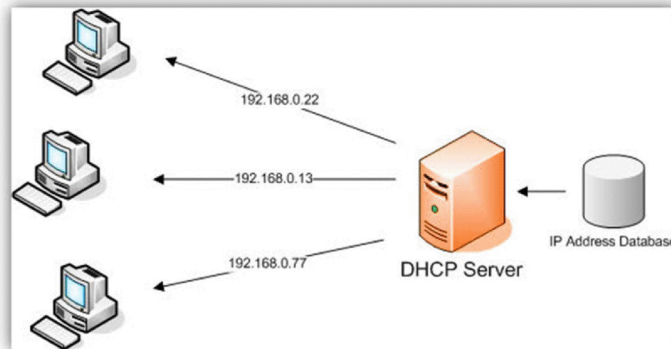
Success rate is 100 percent (5/5), round-trip min/avg/max = 2/4/9 ms



What is DHCP ?

allows a server to dynamically distribute IP addressing and configuration information to clients.

- ▶ IP Address
- ▶ Subnet Mask
- ▶ Default Gateway
- ▶ DNS server

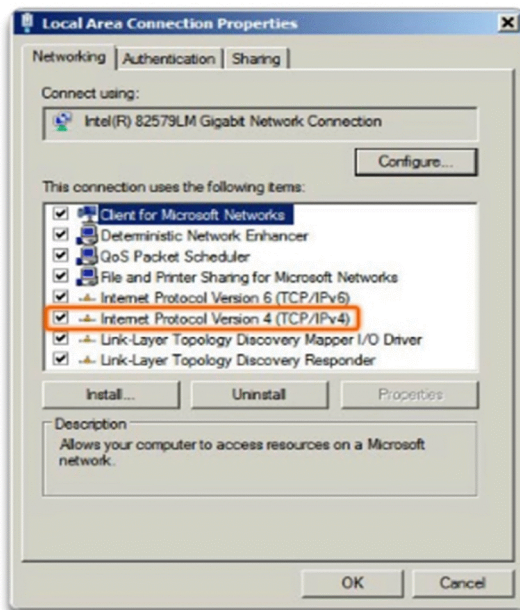


Advantages :

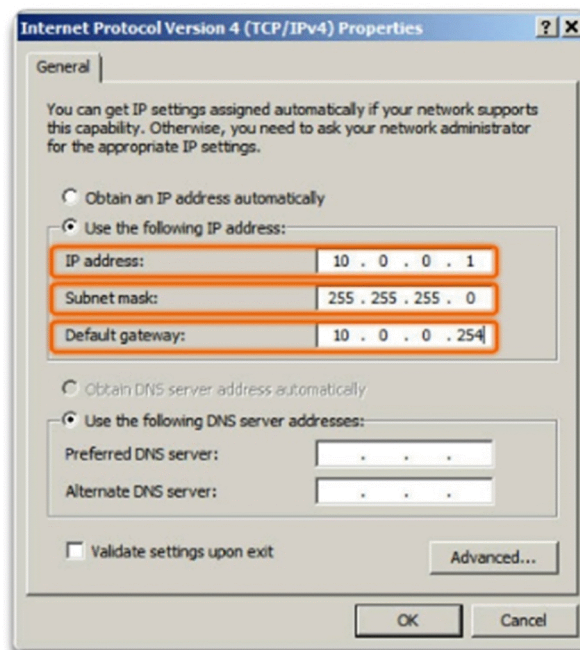
- ▶ Centralized network client configuration
- ▶ easier IP address management
- ▶ Reduced network administration.
- ▶ large network support

Assigning a Static IPv4 Address to a Host

LAN Interface Properties

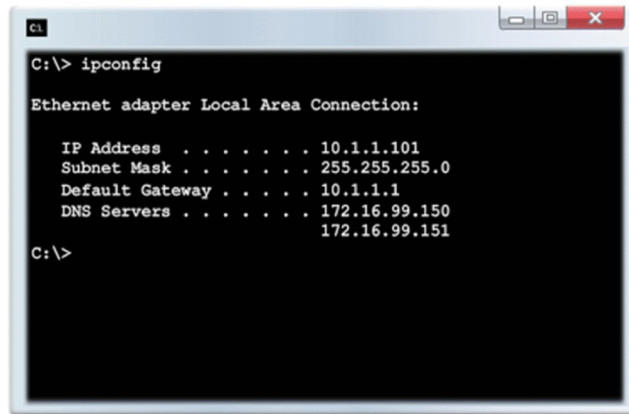
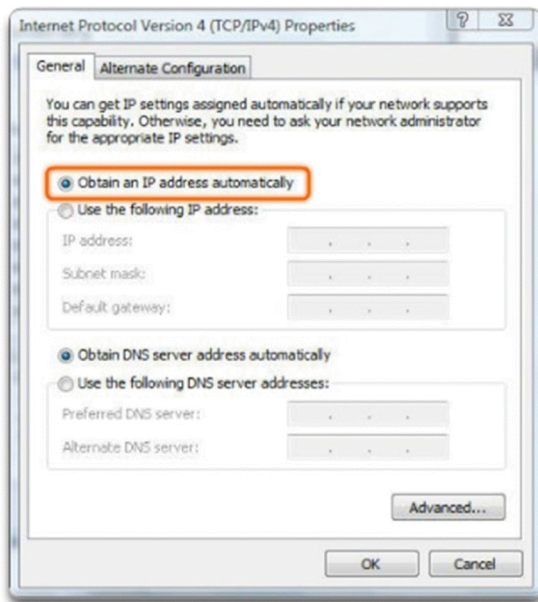


Configuring a Static IPv4 Address



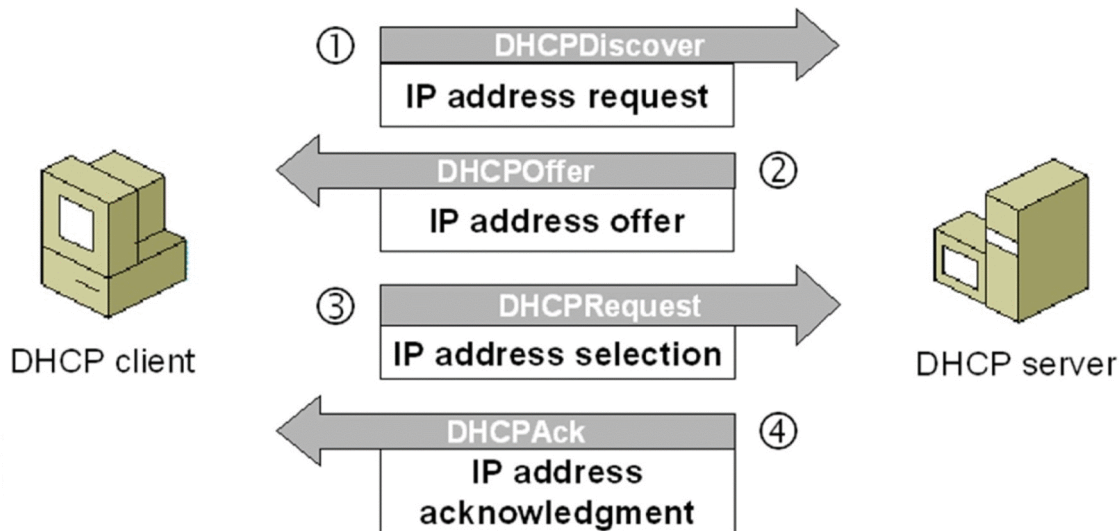
Assigning a Dynamic IPv4 Address to a Host

Assigning a Dynamic IPv4 Address



DHCP - preferred method of "leasing" IPv4 addresses to hosts on large networks, reduces the burden on network support staff and virtually eliminates entry errors

DHCP Process



Router as DHCP server

DHCP(config)#ip dhcp pool CCIE

DHCP(dhcp-config)#?

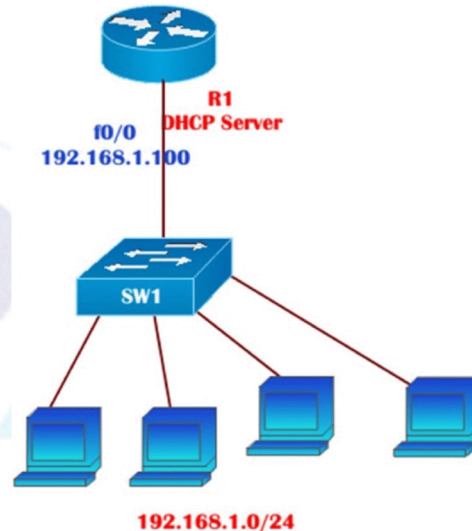
default-router Default routers
dns-server Set name server
exit Exit from DHCP pool configuration mode
network Network number and mask
no Negate a command or set its defaults
option Raw DHCP options

DHCP(dhcp-config)#network 192.168.1.0 255.255.255.0

DHCP(dhcp-config)#default-router 192.168.1.100

DHCP(dhcp-config)#dns-server 192.168.1.50

DHCP(dhcp-config)#dns-server 192.168.1.51



DHCP(config)#ip dhcp excluded-address 192.168.1.100

DHCP(config)#ip dhcp excluded-address 192.168.1.1 192.168.1.10

DHCP(config)#ip dhcp excluded-address 192.168.1.50 192.168.1.51

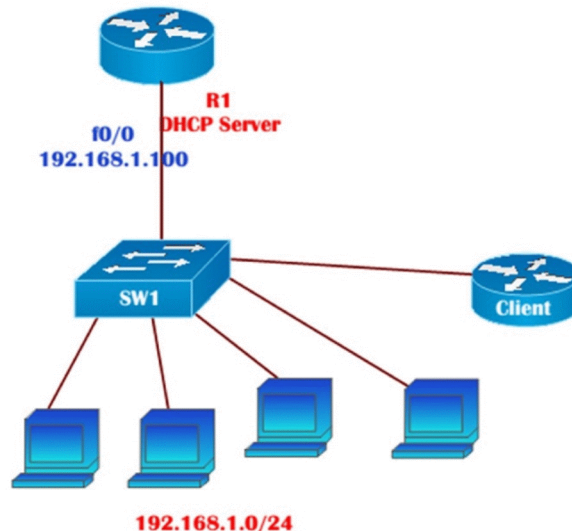
Router as DHCP Client

on client side router

Router(config)# int fa0/0

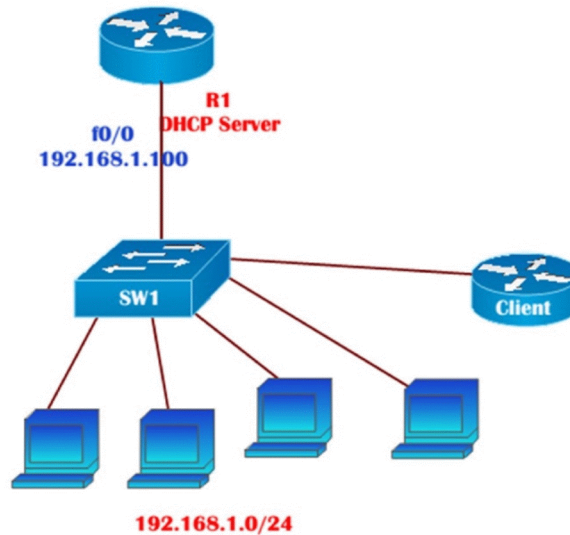
Router(config-if)# ip address dhcp

Router(config-if)# no shut

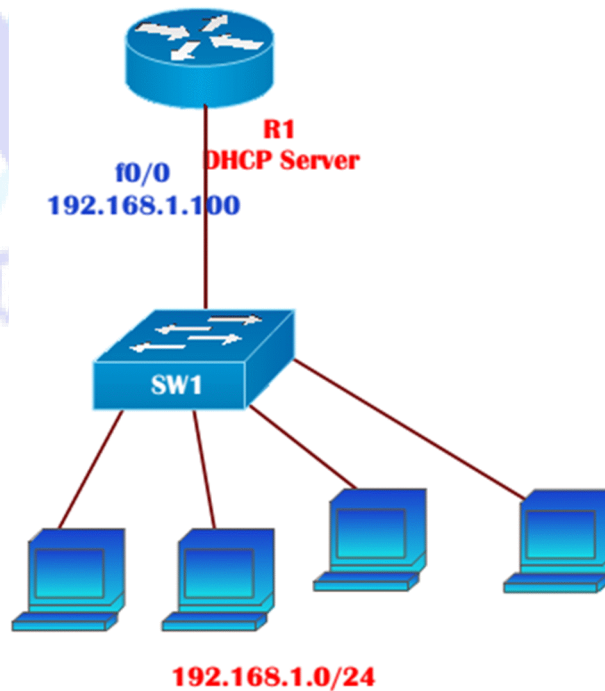


Disadvantage:

- Will increase the load on the router
- Best suited for network that support 10 to 15 users.



LAB: ROUTER AS DHCP SERVER



TASK:

- Configure R1 and PC in the LAN with the IP address as per the diagram given
- Configure R1 as DHCP with the following details
 - Use DHCP pool name "CCIE"
 - Use network 192.168.1.0/24
 - Exclude address 192.168.1.1 -- 192.168.1.10 to 192.168.1.50, 192.168.1.51 , 192.168.1.100
 - IP address of Router is 192.168.1.100

- Dns servers in the Network 192.168.1.50 , 192.168.1.51

```
Router(config)#hostname DHCP
```

```
DHCP(config)#int f0/0
```

```
DHCP(config-if)#ip add 192.168.1.100 255.255.255.0
```

```
DHCP(config-if)#no shutdown
```

```
DHCP(config)#ip dhcp excluded-address ?
```

A.B.C.D Low IP address

```
DHCP(config)#ip dhcp excluded-address 192.168.1.100
```

```
DHCP(config)#ip dhcp excluded-address 192.168.1.1 192.168.1.10
```

```
DHCP(config)#ip dhcp excluded-address 192.168.1.50 192.168.1.51
```

```
DHCP(config)#ip dhcp pool CCIE
```

```
DHCP(dhcp-config)#?
```

default-router Default routers

dns-server Set name server

exit Exit from DHCP pool configuration mode

network Network number and mask

no Negate a command or set its defaults

option Raw DHCP options

```
DHCP(dhcp-config)#network 192.168.1.0 255.255.255.0
```

```
DHCP(dhcp-config)#default-router 192.168.1.100
```

```
DHCP(dhcp-config)#dns-server 192.168.1.50
```

```
DHCP(dhcp-config)#dns-server 192.168.1.51
```

```
DHCP(dhcp-config)#end
```

TO VERIFY ON PC:

```
PC1>ipconfig /release
```

IP Address.....: 0.0.0.0

Subnet Mask.....: 0.0.0.0

Default Gateway.....: 0.0.0.0

DNS Server.....: 0.0.0.0

```
PC1>ipconfig /renew
```

IP Address.....: 192.168.1.11

Subnet Mask.....: 255.255.255.0

Default Gateway.....: 192.168.1.100

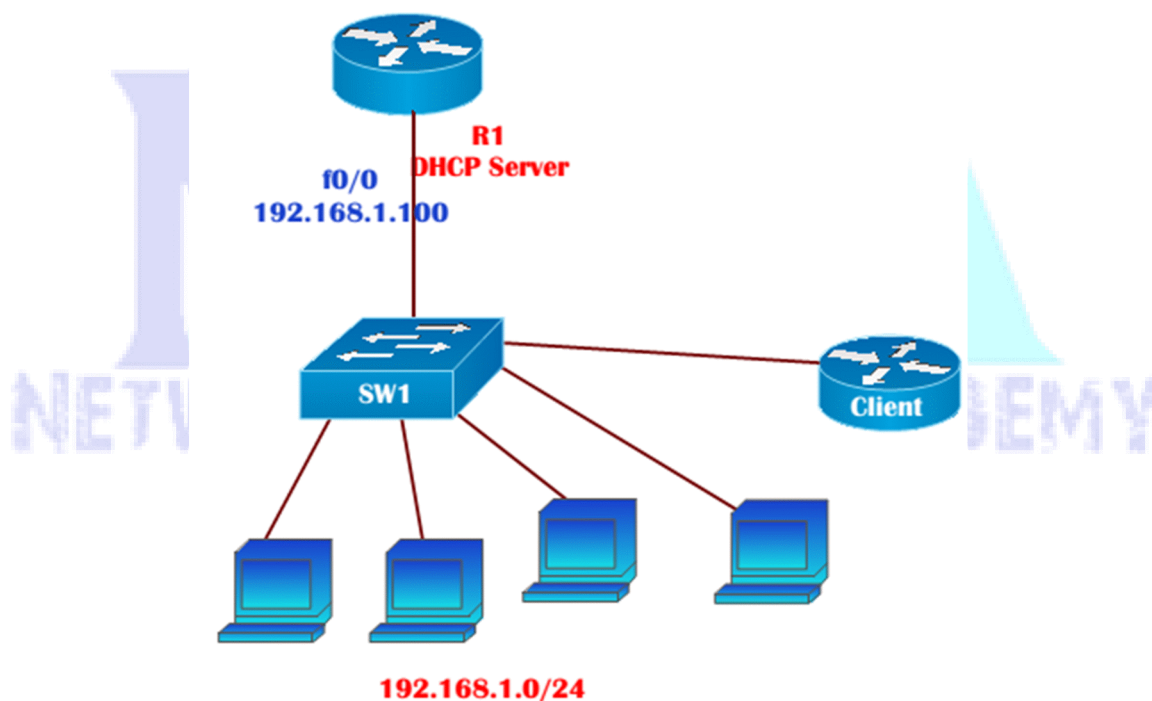
DNS Server.....: 192.168.1.51

```
PC2>ipconfig /release
IP Address.....: 0.0.0.0
Subnet Mask.....: 0.0.0.0
Default Gateway.....: 0.0.0.0
DNS Server.....: 0.0.0.0
```

```
PC2>ipconfig /renew
IP Address.....: 192.168.1.12
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 192.168.1.100
DNS Server.....: 192.168.1.51
```

TASK:

- Connect a Router in the LAN as DHCP client which needs To Get Ip Address Automatically From Dhcp Server.



On client side router

```
Router(config)# int fa0/0
Router(config-if)# ip address dhcp
Router(config-if)# no shut
```

Switch#sh cdp neighbors

```
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - ICMP, r - Repeater, P - Phone
Device ID    Local Intrfce  Holdtme  Capability  Platform  Port ID
DHCP         Fas 0/3       168      R           C2600     Fas 0/0
```


Router Fas 0/6 149 R C2600 Fas 0/0

```
Switch#conf t
Switch(config)#int f0/6
Switch(config-if)#spanning-tree portfast
Switch(config-if)#end
```

Router#sh ip int brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.1.13	YES	DHCP	up	up
FastEthernet0/1	unassigned	YES	unset	administratively down	down

DHCP#sh ip dhcp binding

IP address	Client-ID/ Hardware address	Lease expiration	Type
192.168.1.11	0005.5E88.800B	--	Automatic
192.168.1.12	0001.974D.5308	--	Automatic
192.168.1.13	0002.4AD3.8E01	--	Automatic



Logging on Cisco Routers

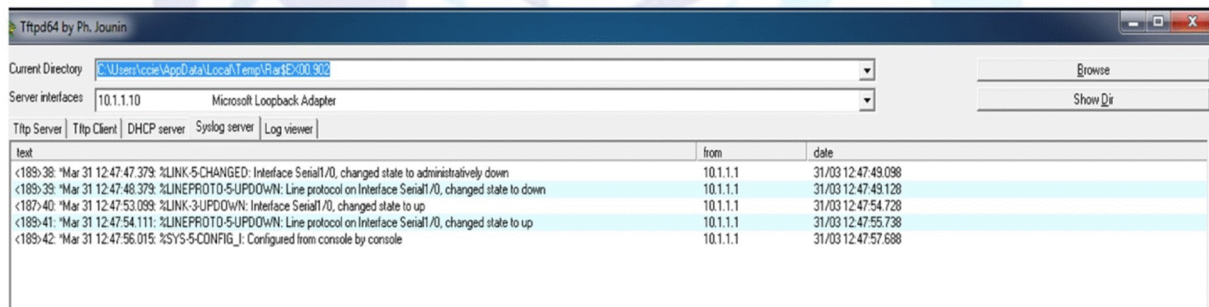
Keeping track of events

- ▶ Console logging
- ▶ Buffered logging
- ▶ Terminal logging
- ▶ Syslog Server logging

```
R1(config)#int s1/0
```

```
R1(config-if)#shutdown
```

```
*Mar 31 10:43:29.931: %LINK-5-CHANGED: Interface Serial1/0, changed state to administratively down
```



Console logging:

- ▶ By default, the router sends all log messages to its console port.
- ▶ Hence only the users that are physically connected to the router console port can view these messages.

```
R1(config)#int s1/0
```

```
R1(config-if)#shutdown
```

```
*Mar 31 10:43:29.931: %LINK-5-CHANGED: Interface Serial1/0, changed state to administratively down
```

```
R1#debug eigrp packets
```

```
(UPDATE, REQUEST, QUERY, REPLY, HELLO, UNKNOWN, PROBE, ACK, STUB, SIAQUERY, SIAREPLY)
```

```
EIGRP Packet debugging is on
```

```
R1#
```

```
R1(config)#router eigrp 100
```

```
R1(config-router)# network 1.0.0.0
```

```
*Mar 31 11:53:29.219: EIGRP: Sending HELLO on Fa0/0 - paklen 20
```

```
*Mar 31 11:53:29.219: AS 100, Flags 0x0:(NULL), Seq 0/0 interfaceQ 0/0 iidbQ un/rely 0/0
```

Buffered logging:

- ▶ This type of logging uses router's RAM for storing log messages.
- ▶ buffer has a fixed size to ensure that the log will not deplete valuable system memory.
- ▶ The router accomplishes this by deleting old messages from the buffer as new messages are added.

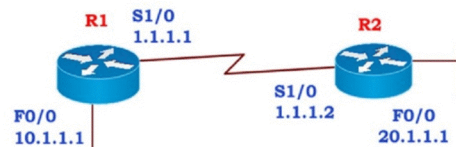
Router(config)# **logging buffered 16384**

show logging

Terminal logging:

- ▶ It is similar to console logging, but it displays log messages to the router's VTY lines instead.
- ▶ This is not enabled by default

Terminal monitor



R1#terminal monitor

R1(config)#int f0/0

R1(config-if)#shutdown

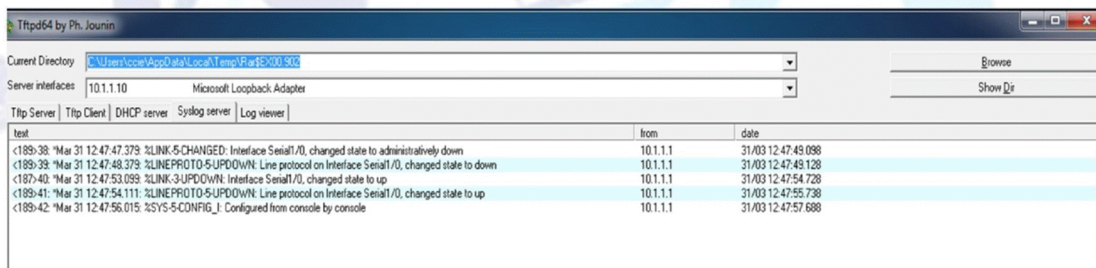
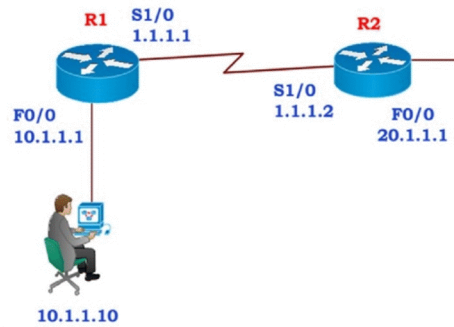
*Mar 31 12:18:29.123: %LINK-5-CHANGED: Interface FastEthernet0/0, changed state to administratively down

*Mar 31 12:18:30.123: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to down

Syslog Server logging :

- ▶ The router can use syslog to forward log messages to external syslog servers for storage.
- ▶ This type of logging is not enabled by default.

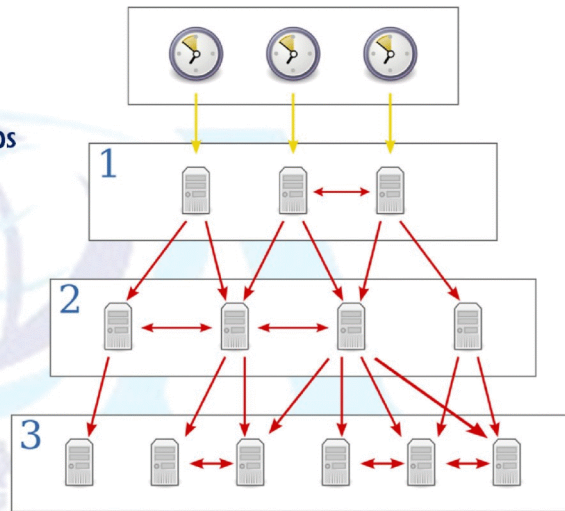
#logging host 10.1.1.10



NOA
NETWORK ONLINE ACADEMY

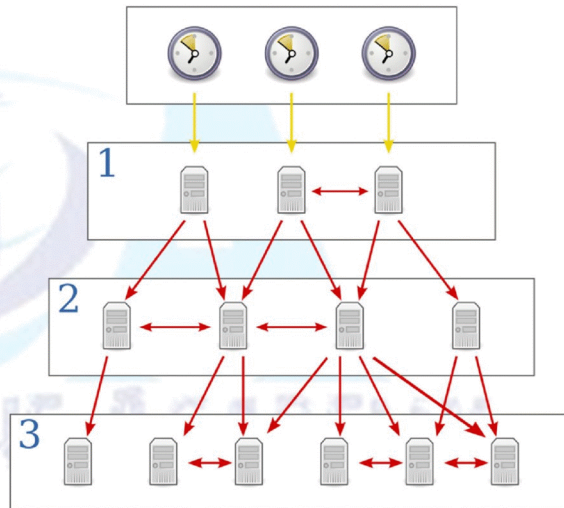
Network Time Protocol (NTP)

- ▶ allow network devices to synchronize their clocks with a central source clock
- ▶ make sure that logging information and timestamps have the accurate time and date.
- ▶ Keep clocks on hosts and network devices synchronized.



Network Time Protocol (NTP)

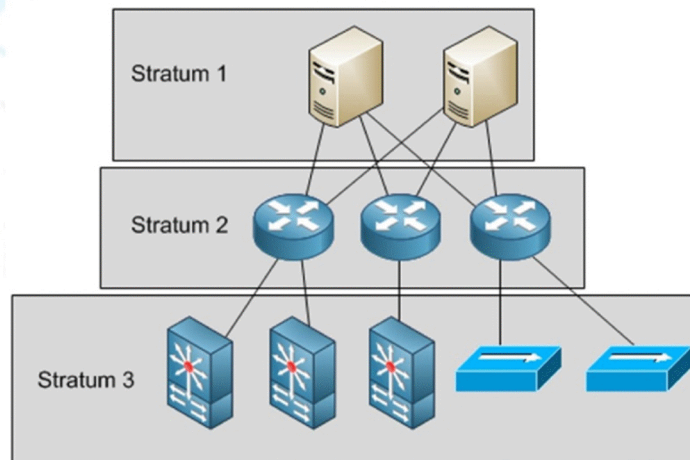
- ▶ gets its time from an authoritative time source, such as a radio clock or an atomic clock attached to a time server.
- ▶ NTP then distributes this time across the network.
- ▶ NTP runs over the User Datagram Protocol (UDP), using port 123 as both the source and destination, which in turn runs over IP.



NTP Stratum

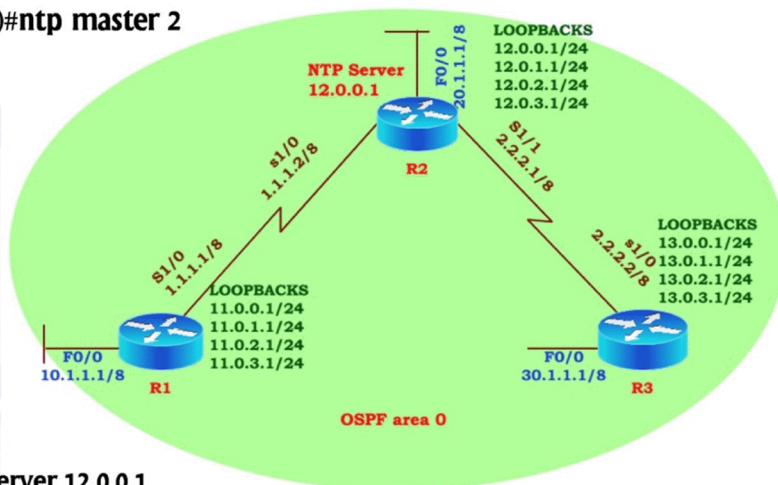
NTP uses a stratum to describe the distance between a network device and an authoritative time source:

- ▶ Stratum 1 time server is directly attached to an authoritative time source (such as a radio or atomic clock or a GPS time source).
- ▶ A stratum 2 NTP server receives its time through NTP from a stratum 1 time server.



NTP Configuration

R2(config)#ntp master 2



R1(config)#ntp server 12.0.0.1

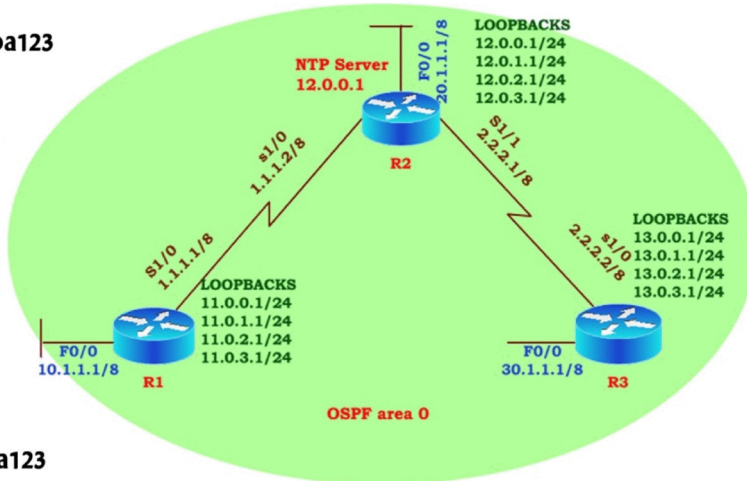
R3(config)#ntp server 12.0.0.1

R1#sh ntp status

R1#sh ntp associations

NTP Authentication

```
R2(config)# ntp authentication-key 1 md5 noa123
R2(config)# ntp authenticate
R2(config)# ntp trusted-key 1
```

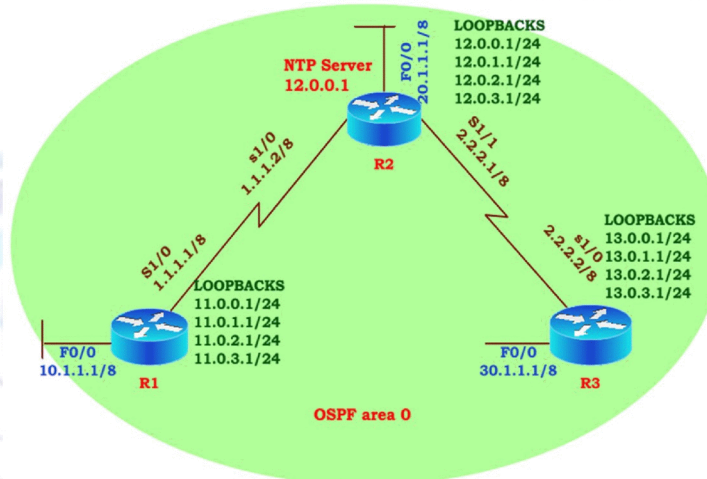


On R1 & R3

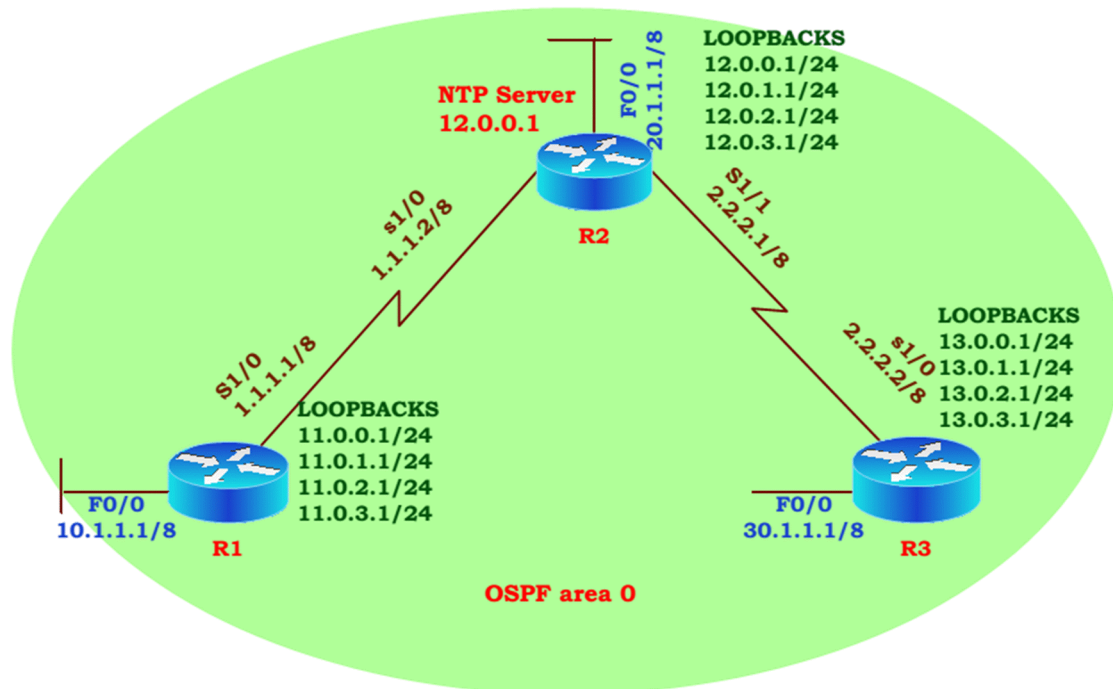
```
Rx(config)# ntp authentication-key 1 md5 noa123
Rx(config)# ntp authenticate
Rx(config)# ntp trusted-key 1
Rx(config)# ntp server 12.0.0.1 key 1
```

NTP Troubleshooting

- ▶ Access control lists that do not permit UDP port 123 packets to come through
- ▶ Misconfiguration in the routers, such as the clock time-zone and clock summer-time commands are absent on the routers
- ▶ Public time server is down



- ▶ More traffic is on the router and more traffic on the way to the server
- ▶ NTP master lost sync and router loses sync periodically
- ▶ High CPU utilization
- ▶ High offset and more between the server and the router (use the show ntp association detail command to check for this)



TASK:

- Change the time on R2 to 10:10:10 and 10 january 2015 time.
- Configure R2 as NTP server and R1/R3 as NTP clients
- Ensure that R1/R3 should change their time as per R2 (NTP server).

```
R1(config)#router ospf 1
R1(config-router)#network 10.0.0.0 0.255.255.255 area 0
R1(config-router)#network 1.0.0.0 0.255.255.255 area 0
R1(config-router)#network 11.0.0.0 0.255.255.255 area 0
R1(config-router)#exit
```

```
R2(config)#router ospf 1
R2(config-router)#network 20.0.0.0 0.255.255.255 area 0
R2(config-router)#network 2.0.0.0 0.255.255.255 area 0
R2(config-router)#network 1.0.0.0 0.255.255.255 area 0
R2(config-router)#network 12.0.0.0 0.255.255.255 area 0
R2(config-router)#end
```

```
R3(config)#router ospf 1
R3(config-router)#network 2.0.0.0 0.255.255.255 area 0
R3(config-router)#network 13.0.0.0 0.255.255.255 area 0
R3(config-router)#network 30.0.0.0 0.255.255.255 area 0
R3(config-router)#end
```

R2#sh ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface
11.0.3.1	0	FULL/ -	00:00:34	1.1.1.1	Serial1/0
13.0.3.1	0	FULL/ -	00:00:32	2.2.2.2	Serial1/1

R2#sh ip route ospf

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
ia - IS-IS inter area, * - candidate default, U - per-user static route
o - ODR, P - periodic downloaded static route, H - NHRP, I - LISP
+ - replicated route, % - next hop override

Gateway of last resort is not set

- 10.0.0.0/8 [110/65] via 1.1.1.1, 00:00:36, Serial1/0
11.0.0.0/32 is subnetted, 4 subnets
- 11.0.0.1 [110/65] via 1.1.1.1, 00:00:36, Serial1/0
- 11.0.1.1 [110/65] via 1.1.1.1, 00:00:36, Serial1/0
- 11.0.2.1 [110/65] via 1.1.1.1, 00:00:36, Serial1/0
- 11.0.3.1 [110/65] via 1.1.1.1, 00:00:36, Serial1/0
- 13.0.0.0/32 is subnetted, 4 subnets
- 13.0.0.1 [110/65] via 2.2.2.2, 00:00:13, Serial1/1
- 13.0.1.1 [110/65] via 2.2.2.2, 00:00:13, Serial1/1
- 13.0.2.1 [110/65] via 2.2.2.2, 00:00:13, Serial1/1
- 13.0.3.1 [110/65] via 2.2.2.2, 00:00:13, Serial1/1
- 30.0.0.0/8 [110/65] via 2.2.2.2, 00:00:13, Serial1/1

R2#clock set 10:10:10 10 January 2015

R2#sh clock

10:10:18.775 UTC Sat Jan 10 2015

R2(config)#ntp master 2

R2(config)#end

R2#sh ntp status

Clock is synchronized, stratum 2, reference is 127.127.1.1
nominal freq is 250.0000 Hz, actual freq is 250.0000 Hz, precision is 2**18
ntp uptime is 1700 (1/100 of seconds), resolution is 4000
reference time is D85B7952.9AA33984 (10:11:30.604 UTC Sat Jan 10 2015)
clock offset is 0.0000 msec, root delay is 0.00 msec
root dispersion is 3937.56 msec, peer dispersion is 3937.56 msec

loopfilter state is 'CTRL' (Normal Controlled Loop), drift is 0.000000000 s/s
system poll interval is 16, last update was 1 sec ago.

R2#sh ntp associations

address	ref clock	st	when	poll	reach	delay	offset	disp
*~127.127.1.1	.LOCL.	1	12	16	3	0.000	0.000	3937.5

* sys.peer, # selected, + candidate, - outlier, x falseticker, ~ configured

R1#ping 12.0.0.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 12.0.0.1, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 96/117/156 ms

R1(config)#ntp server 12.0.0.1

R1(config)#exit

R3# ping 12.0.0.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 12.0.0.1, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 52/111/152 ms

R3(config)#ntp server 12.0.0.1

R3(config)#end

R3#sh ntp associations

address	ref clock	st	when	poll	reach	delay	offset	disp
*~12.0.0.1	127.127.1.1	2	0	64	1	143.93	108.054	1937.5

* sys.peer, # selected, + candidate, - outlier, x falseticker, ~ configured

R3#sh clock

10:14:54.412 UTC Sat Jan 10 2015

R1#sh clock

10:15:02.137 UTC Sat Jan 10 2015

R1#sh ntp associations

address	ref clock	st	when	poll	reach	delay	offset	disp
*~12.0.0.1	127.127.1.1	2	39	64	1	103.92	-22.228	187.62

* sys.peer, # selected, + candidate, - outlier, x falseticker, ~ configured

R1#sh ntp status

Clock is synchronized, stratum 3, reference is 12.0.0.1

nominal freq is 250.0000 Hz, actual freq is 250.0000 Hz, precision is 2**18

ntp uptime is 6100 (1/100 of seconds), resolution is 4000
reference time is D85B79F9.59A974A1 (10:14:17.350 UTC Sat Jan 10 2015)
clock offset is -22.2285 msec, root delay is 103.92 msec
root dispersion is 4098.93 msec, peer dispersion is 187.62 msec
loopfilter state is 'CTRL' (Normal Controlled Loop), drift is 0.000000000 s/s
system poll interval is 64, last update was 56 sec ago.



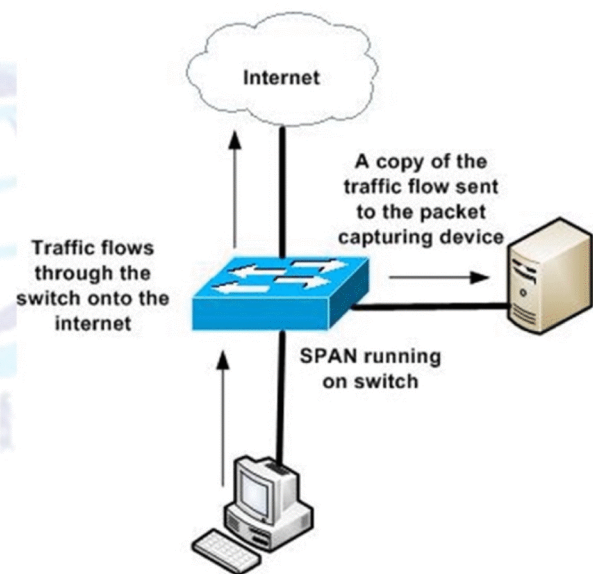
Switch port Analyzer

SPAN, RSPAN, ERSPAN

Switch port Analyzer (SPAN)

Cisco Catalyst switches support a method of directing all traffic from a source port or source VLAN to a single port.

- It is useful for many applications which includes **monitoring traffic for compliance reasons, data collection purposes, or to support a particular application.**
- For example, all traffic from a **voice VLAN** can be delivered to a single switch port to facilitate call recording in a VoIP network.
- Another common use of this feature is to **support intrusion detection/prevention system (IDS/IPS) security solutions.**



LAB-1 : SPAN

Mirror traffic sent or received from interface fa0/12 to interface fa0/24. All traffic sent or received on fa0/12 is sent to fa0/24.

```
SWITCH(config)# monitor session 1 source interface fa0/12
```

```
SWITCH(config)# monitor session 1 destination interface fa0/24
```

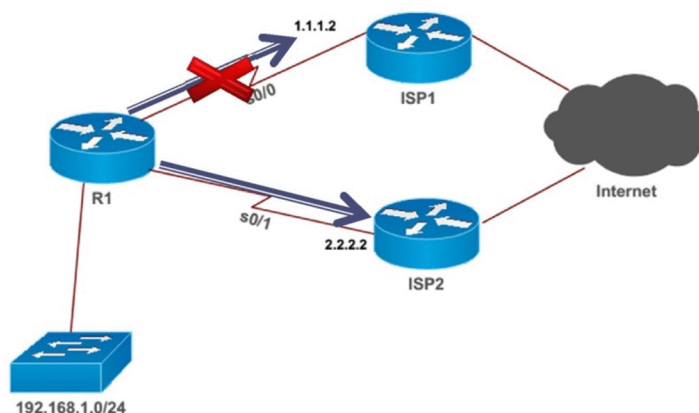


support three types of traffic: transmitted, received, and both.

First Hop Redundancy protocols

HSRP , VRRP , GLBP

Floating Default routes – Redundancy

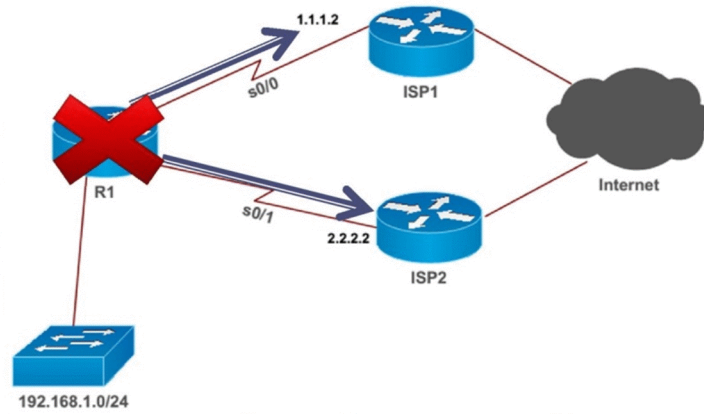


```
R1(Config)# IP route 0.0.0.0 0.0.0.0 1.1.1.2
```

```
R1(Config)# IP route 0.0.0.0 0.0.0.0 2.2.2.2 10
```

What if the Gateway goes down

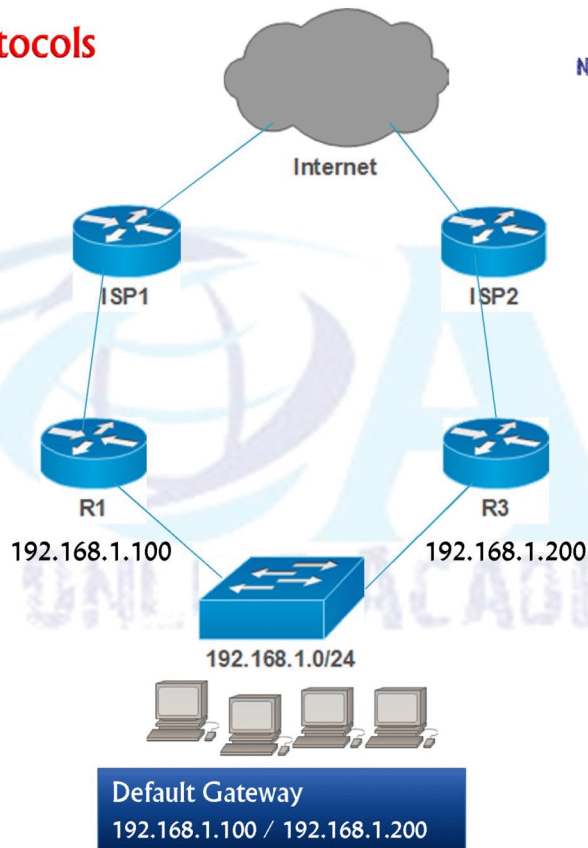
- ▶ Single point of failure
- ▶ No redundancy for gateway



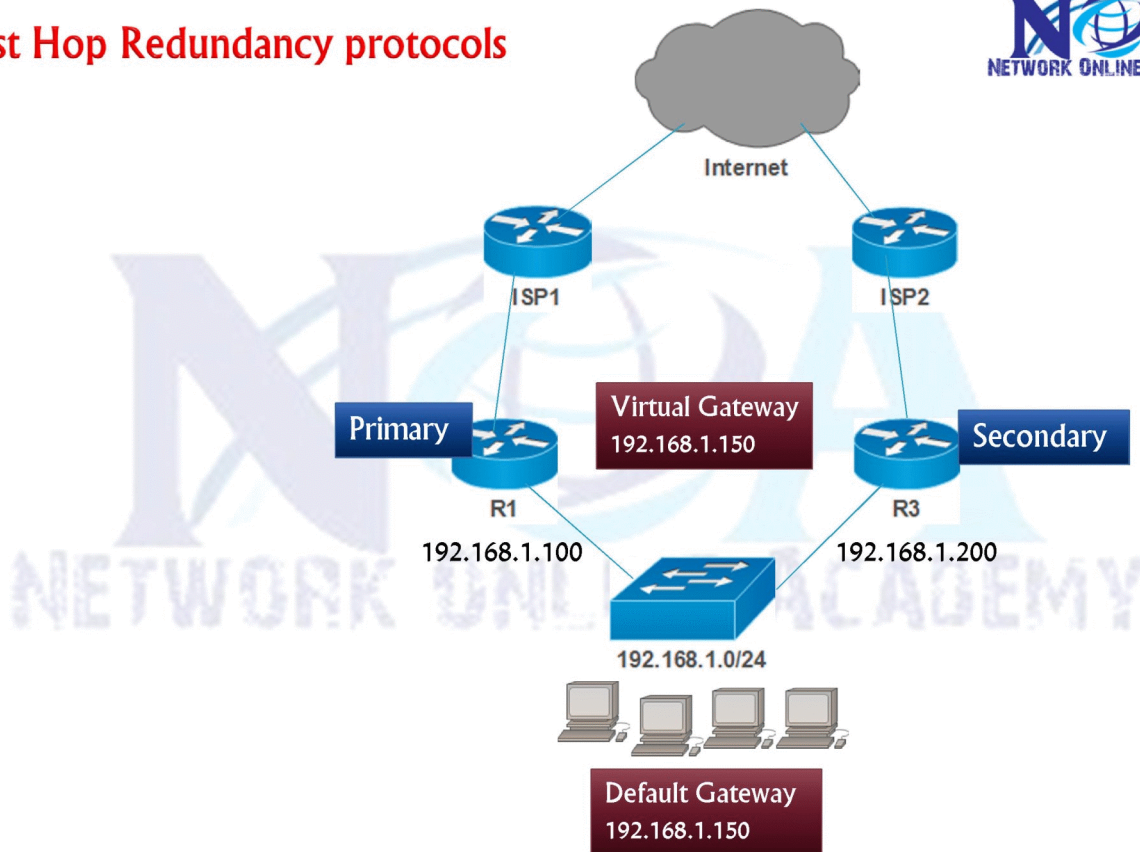
R1(Config)# IP route 0.0.0.0 0.0.0.0 1.1.1.2

R1(Config)# IP route 0.0.0.0 0.0.0.0 2.2.2.2 10

First Hop Redundancy protocols



First Hop Redundancy protocols



FHRP Protocols

	HSRP	VRRP	GLBP
Scope	Cisco Proprietary	IEEE standard	Cisco proprietary
Standard	RFC2281	RFC3768	None
Load Balancing	No	No	Yes
Multicast Group IP address	224.0.0.2 in ver 1 224.0.0.102 in ver 2	224.0.0.18	224.0.0.102
Transport PortNumber	UDP 1985	UDP 112	UDP 3222
Timers	Hello – 3 sec	Advertisement – 1 sec	Hello – 3sec
	Hold – 10 sec	Master down time = 3*Advertisement Time + Skew Time Skew Time = (256- Priority)/256	Hold – 10sec

FHRP protocols

	HSRP	VRRP	GLBP
Election	Highest Priority Highest IP address Tiebreaker)	Highest Priority Highest IP (Tiebreaker)	Highest Priority Highest IP (Tiebreaker)
Router Role	One Active Router one Standby Router	One Active Router One or More Backup Routers	One AVG up to 4 AVF Routers
Preempt	By default is disabled	By default is enabled	By default is disabled
Group Virtual Mac Address	0000.0c07.acxx	0000.5e00.01xx	0007.b4xx.xxxx
IPv6 support	Version 2	Version 3	Yes

HSRP – Basic setup

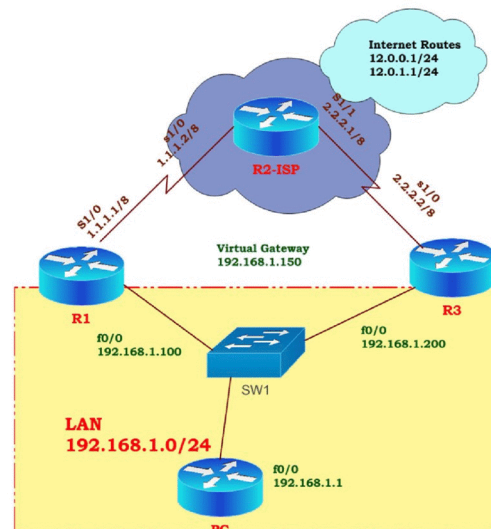
Static – Default Routing to provide Reachability

R1(config)#ip route 0.0.0.0 0.0.0.0 1.1.1.2

R3(config)#ip route 0.0.0.0 0.0.0.0 2.2.2.1

R2(config)#ip route 192.168.1.0 255.255.255.0 1.1.1.1

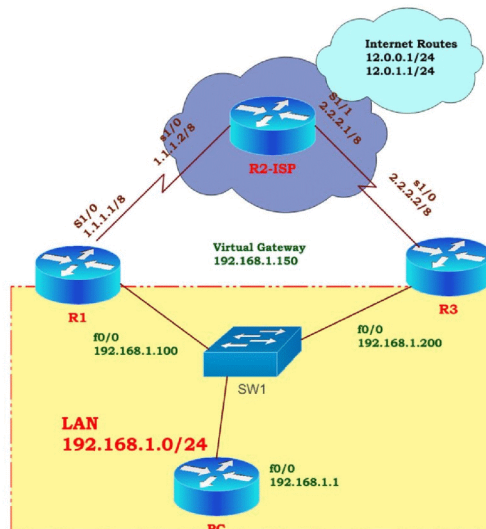
R2(config)#ip route 192.168.1.0 255.255.255.0 2.2.2.2



HSRP – Configuration

```
R1(config)#int fa0/0
R1(config-if)#standby 12 ip 192.168.1.150
R1(config-if)#standby 12 priority 120
R1(config-if)#standby 12 preempt
R1(config-if)#standby 12 track s1/0 30
```

```
R3(config)#int fa0/0
R3(config-if)#standby 12 ip 192.168.1.150
R3(config-if)#standby 12 preempt
```



R1#sh standby

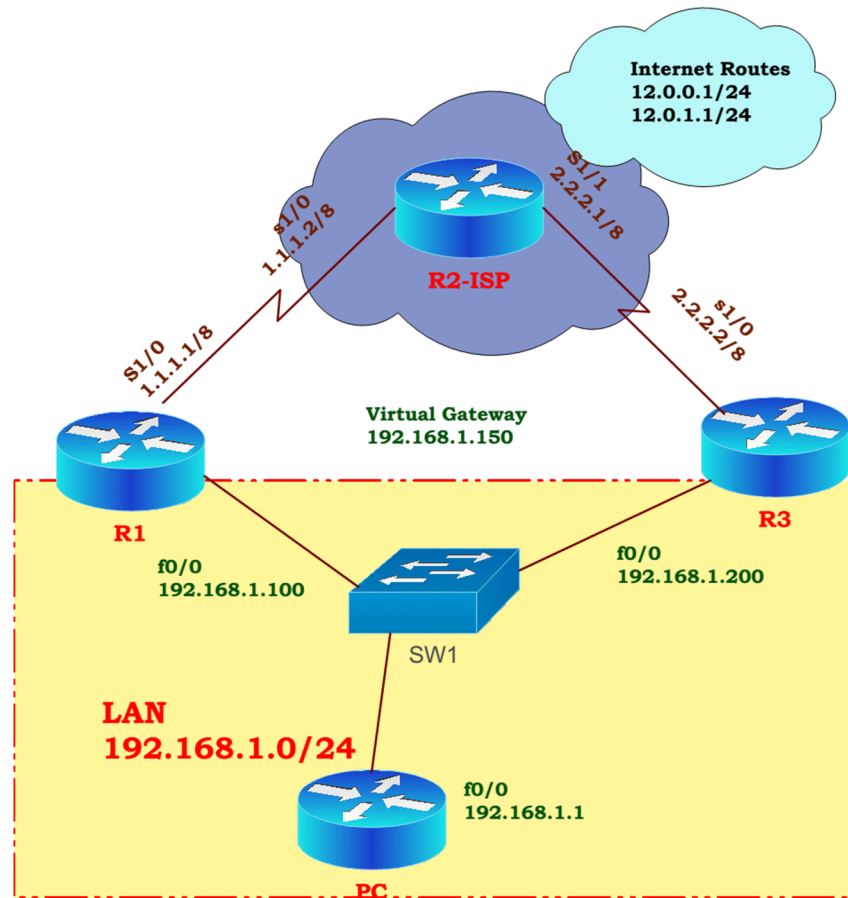
```
FastEthernet0/0 - Group 12
State is Active
  2 state changes, last state change 00:03:03
Virtual IP address is 192.168.1.150
Active virtual MAC address is 0000.0c07.ac0c
Local virtual MAC address is 0000.0c07.ac0c (v1 default)
Hello time 3 sec, hold time 10 sec
Next hello sent in 0.720 secs
Preemption enabled
Active router is local
Standby router is 192.168.1.200, priority 100 (expires in 4.724 sec)
Priority 120 (configured 120)
Track interface Serial1/0 state Up decrement 30
IP redundancy name is "hsrp-Fa0/0-12" (default)
```

R1#sh standby brief

P indicates configured to preempt.

Interface	Grp	Prio	P	State	Active	Standby	Virtual IP
Fa0/0	12	120	P	Active	local	192.168.1.200	192.168.1.150

LAB: HOT STANDBY ROUTER PROTOCOL (HSRP)



TASK:

- Configure the Basic IP addressing on Routers as per the Diagram & test Connectivity
- Configure Default Route on R1/R3 to reach routes on Internet
- Configure Static Route on R2-ISP back to LAN network on both Sides

```
R1(config)#int f0/0
R1(config-if)#ip add 192.168.1.100 255.255.255.0
R1(config-if)#no sh
R1(config-if)#end
```

```
R3(config)#int f0/0
R3(config-if)#ip add 192.168.1.200 255.255.255.0
R3(config-if)#no sh
```

```
R1(config)#ip route 0.0.0.0 0.0.0.0 1.1.1.2
```

```
R3(config)#ip route 0.0.0.0 0.0.0.0 2.2.2.1
```

```
R2(config)#ip route 192.168.1.0 255.255.255.0 1.1.1.1
```

```
R2(config)#ip route 192.168.1.0 255.255.255.0 2.2.2.2
```

```
R3#ping 192.168.1.100
```

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.1.100, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 28/45/96 ms

TASK:

- Configure HSRP on R1 and R3 under f0/0 and use Virtual Gateway IP address as 192.168.1.150/24.
- Make sure that R1 becomes primary and R2 as backup.
- Active Gateway Priority 120 and the Standby are left at the default.
- Authentication between both switches - md5 – password “cisco
- Standby will take up active role in a 5 seconds incase if 5 hello packets not received
- The primary gateway should have the ability to resume the Primary role once primary router or track interface is reachable (preempt)
- Make sure that the reachability to internet should be established even if the WAN interface (R1 s1/0) goes down

```
R1(config)#int fa0/0
```

```
R1(config-if)#standby 12 ip 192.168.1.150
```

```
R1(config-if)#standby 12 priority 120
```

```
R1(config-if)#standby 12 preempt
```

```
R1(config-if)#standby 12 authentication md5 key-string cisco
```

```
R1(config-if)#standby 12 track s1/0 30
```

```
R1(config-if)#standby 12 timers 1 5
```

```
R3(config)#int fa0/0
```

```
R3(config-if)#standby 12 ip 192.168.1.150
```

```
R3(config-if)#standby 12 preempt
```

```
R3(config-if)# standby 12 authentication md5 key-string cisco
```

```
R3(config-if)#standby 12 timers 1 5
```

```
R1#sh standby
```

FastEthernet0/0 - **Group 12**

State is Active

2 state changes, last state change 00:03:03

Virtual IP address is 192.168.1.150

Active virtual MAC address is 0000.0c07.ac0c

Local virtual MAC address is 0000.0c07.ac0c (v1 default)

Hello time 1 sec, hold time 5 sec

Next hello sent in 0.720 secs

Authentication MD5, key-string "cisco"

Preemption enabled

Active router is local

Standby router is 192.168.1.200, priority 100 (expires in 4.724 sec)

Priority 120 (configured 120)

Track interface Serial1/0 state Up decrement 30

IP redundancy name is "hsrp-Fa0/0-12" (default)

R1#sh standby brief

P indicates configured to preempt.

	Interface	Grp	Prio	P State	Active	Standby	Virtual IP
Fa0/0	12	120	P	Active	local	192.168.1.200	192.168.1.150

R3#sh standby

FastEthernet0/0 - Group 12

State is Standby

4 state changes, last state change 00:05:55

Virtual IP address is 192.168.1.150

Active virtual MAC address is 0000.0c07.ac0c

Local virtual MAC address is 0000.0c07.ac0c (v1 default)

Hello time 1 sec, hold time 5 sec

Next hello sent in 0.252 secs

Authentication MD5, key-string "cisco"

Preemption enabled

- Active router is 192.168.1.100, priority 120 (expires in 4.524 sec)

Standby router is local

Priority 100 (default 100)

IP redundancy name is "hsrp-Fa0/0-12" (default)

R3#sh standby brief

P indicates configured to preempt.

	Interface	Grp	Prio	P State	Active	Standby	Virtual IP
Fa0/0	12	100	P	Standby	192.168.1.100	local	192.168.1.150

TASK:

- Assuming the router R4 as the PC connected in LAN, Configure Client routers for Verification in the LAN

On R4

Client1(config)#hostname Client-R4

Client-R4(config)#no ip routing

Client-R4(config)#int f0/0

Client-R4(config-if)#ip add 192.168.1.1 255.255.255.0

Client-R4(config-if)#exit

Client-R4(config)#ip default-gateway 192.168.1.150

Client-R4(config)#end

Client-R4#ping 192.168.1.150

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.1.150, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 4/237/1108 ms

Client-R4#ping 192.168.1.100

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.1.100, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/215/1036 ms

Client-R4#ping 192.168.1.200

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.1.200, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/225/1052 ms

Client-R4#traceroute 12.0.0.1

Type escape sequence to abort.

Tracing the route to 12.0.0.1

1 192.168.1.100 48 msec 120 msec 28 msec

2 1.1.1.2 40 msec 144 msec *

R1(config)#int f0/0

R1(config-if)#shutdown

Client1#ping 12.0.0.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 12.0.0.1, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/72/172 ms

Client1#traceroute 12.0.0.1

Type escape sequence to abort.

Tracing the route to 12.0.0.1

1 192.168.1.200 168 msec 108 msec 44 msec

2 2.2.2.1 108 msec 172 msec

R3#sh standby

FastEthernet0/0 - Group 12

State is Active

2 state changes, last state change 00:00:06

Virtual IP address is 192.168.1.150
Active virtual MAC address is 0000.0c07.ac0c
Local virtual MAC address is 0000.0c07.ac0c (v1 default)
Hello time 1 sec, hold time 5 sec
Next hello sent in 0.244 secs
Authentication MD5, key-string "cisco"
Preemption enabled
Active router is local
Standby router is unknown
Priority 100 (default 100)
IP redundancy name is "hsrp-Fa0/0-12" (default)

```
R1(config)#int f0/0
R1(config-if)#no shutdown
R1(config-if)#end
```

R3#sh standby

FastEthernet0/0 - Group 12
State is Standby
4 state changes, last state change 00:00:07
Virtual IP address is 192.168.1.150
Active virtual MAC address is 0000.0c07.ac0c
Local virtual MAC address is 0000.0c07.ac0c (v1 default)
Hello time 1 sec, hold time 5 sec
Next hello sent in 0.316 secs
Authentication MD5, key-string "cisco"
Preemption enabled
Active router is 192.168.1.100, priority 120 (expires in 4.380 sec)
Standby router is local
Priority 100 (default 100)
IP redundancy name is "hsrp-Fa0/0-12" (default)

R1#sh standby

FastEthernet0/0 - Group 12
State is Active
4 state changes, last state change 00:01:07
Virtual IP address is 192.168.1.150
Active virtual MAC address is 0000.0c07.ac0c
Local virtual MAC address is 0000.0c07.ac0c (v1 default)
Hello time 1 sec, hold time 5 sec
Next hello sent in 0.896 secs
Authentication MD5, key-string "cisco"
Preemption enabled
Active router is local
Standby router is 192.168.1.200, priority 100 (expires in 4.912 sec)

Priority 120 (configured 120)
Track interface Serial1/0 state Up decrement 30
IP redundancy name is "hsrp-Fa0/0-12" (default)

```
R1(config)#int s1/0
R1(config-if)#shutdown
R1(config-if)#end
```

R1#sh standby

FastEthernet0/0 - Group 12
State is Standby
6 state changes, last state change 00:00:30
Virtual IP address is 192.168.1.150
Active virtual MAC address is 0000.0c07.ac0c
Local virtual MAC address is 0000.0c07.ac0c (v1 default)
Hello time 1 sec, hold time 5 sec
Next hello sent in 0.648 secs
Authentication MD5, key-string "cisco"
Preemption enabled
Active router is 192.168.1.200, priority 100 (expires in 4.740 sec)
Standby router is local
Priority 90 (configured 120)
Track interface Serial1/0 state Down decrement 30
IP redundancy name is "hsrp-Fa0/0-12" (default)

```
R1(config)#int s1/0
R1(config-if)#no shutdown
R1(config-if)#end
```

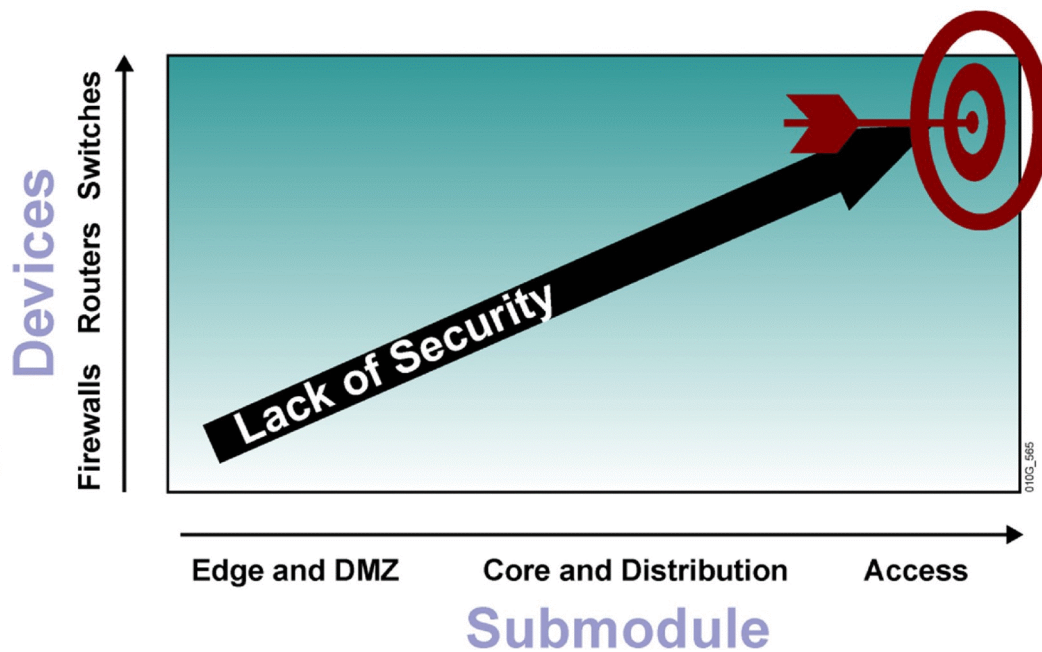
R1#sh standby

FastEthernet0/0 - Group 12
State is Active
7 state changes, last state change 00:00:11
Virtual IP address is 192.168.1.150
Active virtual MAC address is 0000.0c07.ac0c
Local virtual MAC address is 0000.0c07.ac0c (v1 default)
Hello time 1 sec, hold time 5 sec
Next hello sent in 0.876 secs
Authentication MD5, key-string "cisco"
Preemption enabled
Active router is local
Standby router is 192.168.1.200; priority 100 (expires in 4.964 sec)
Priority 120 (configured 120)

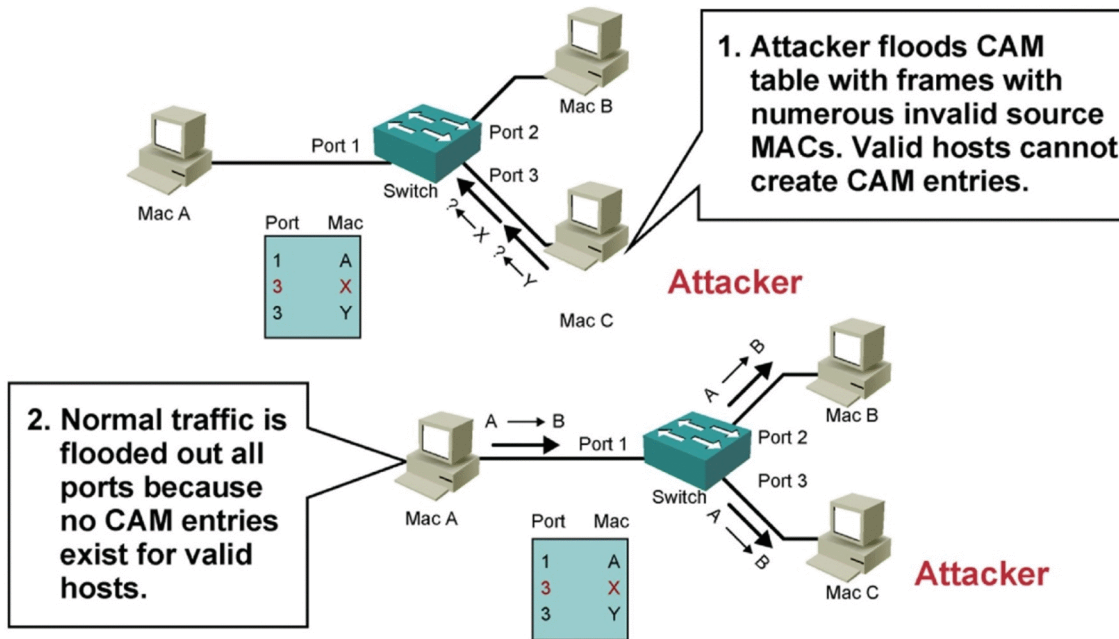
Track interface Serial1/0 state Up decrement 30
IP redundancy name is "hsrp-Fa0/0-12" (default)

Understanding Switch Security Issues

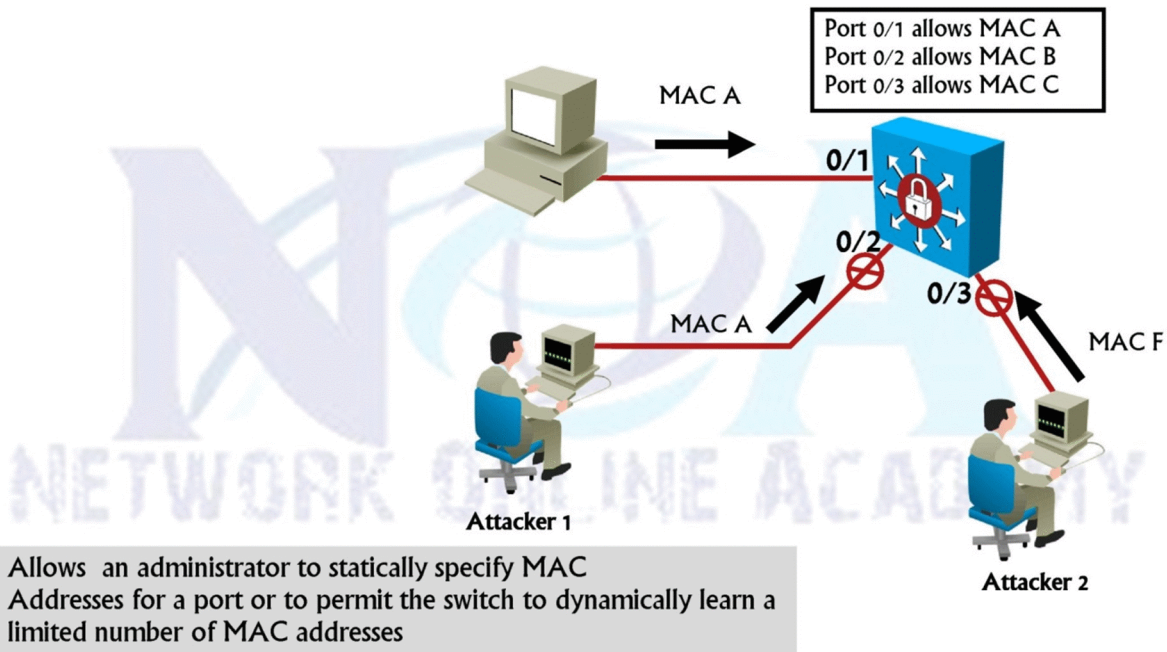
Overview of Switch Security



MAC Flooding Attack

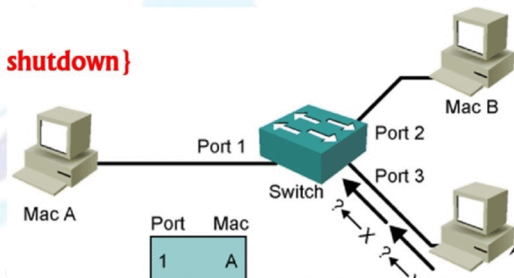


Port Security Overview



Port Security Configuration

```
(config)# interface f0/1
(config-if)# switchport mode access
(config-if)# switchport port-security
(config-if)# switchport port-security maximum value
(config-if)# switchport port-security violation {protect | restrict | shutdown}
```



Note:

- The default “shutdown” action
- Default maximum mac-address = 1
- Port-security works only on ports configured as static access or static trunks (does not work on dynamic ports)

Port-Security Violation Parameters

```
(config-if)# switchport port-security violation {protect | restrict | shutdown}
```

Shutdown

- port immediately is put into the Err-disable state

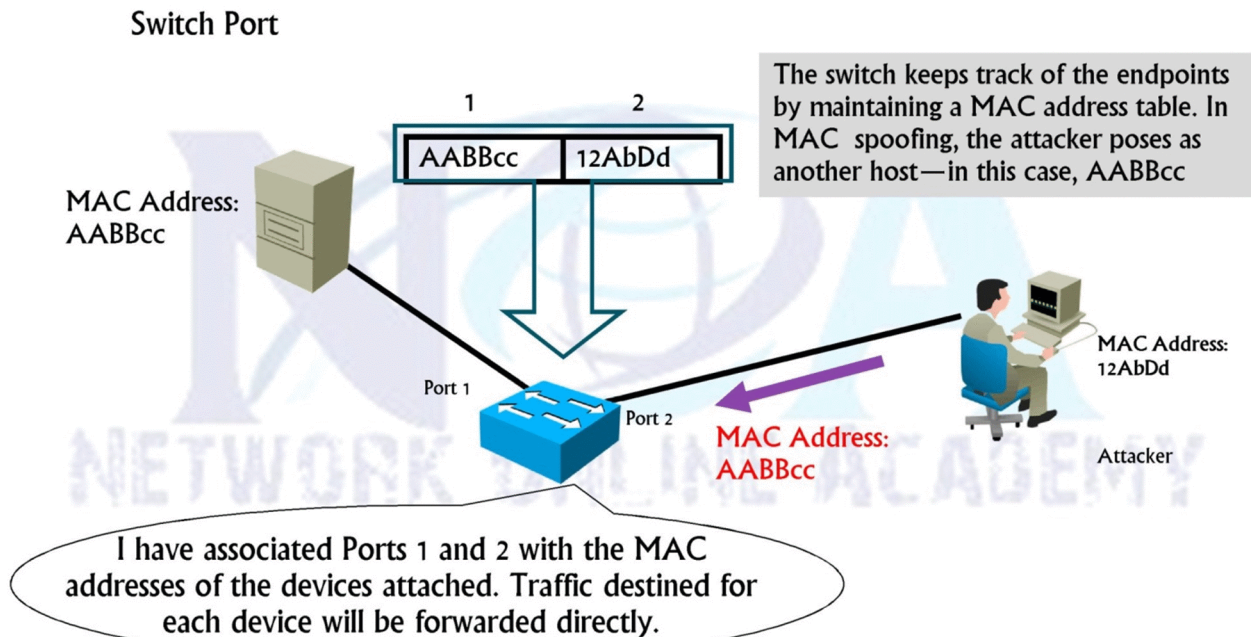
Protect

- The port is allowed to stay up, as in the restrict mode.
- Reaches its MAC address limit, the port stops learning MAC addresses
- Although packets from violating addresses are dropped, no record of the violation is kept.

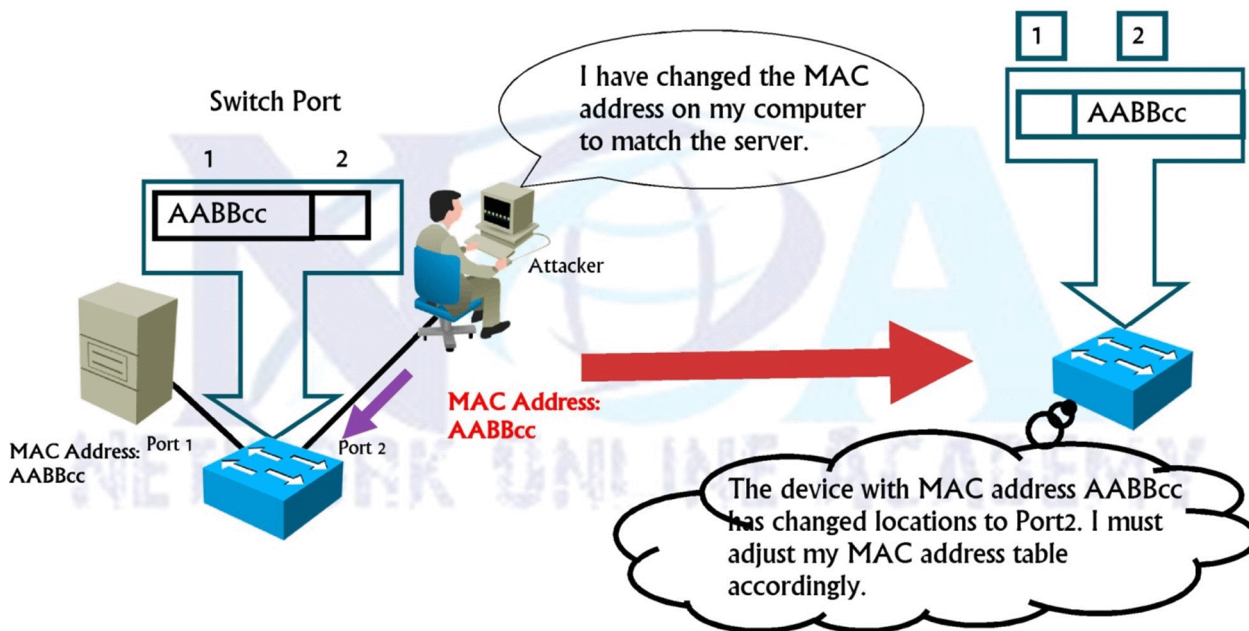
Restrict

- The port is allowed to stay up, but all packets from violating MAC addresses are dropped.
- The switch keeps a running count of the number of violating packets and can send an SNMP trap and a syslog message as an alert of the violation.

MAC Address Spoofing Attack

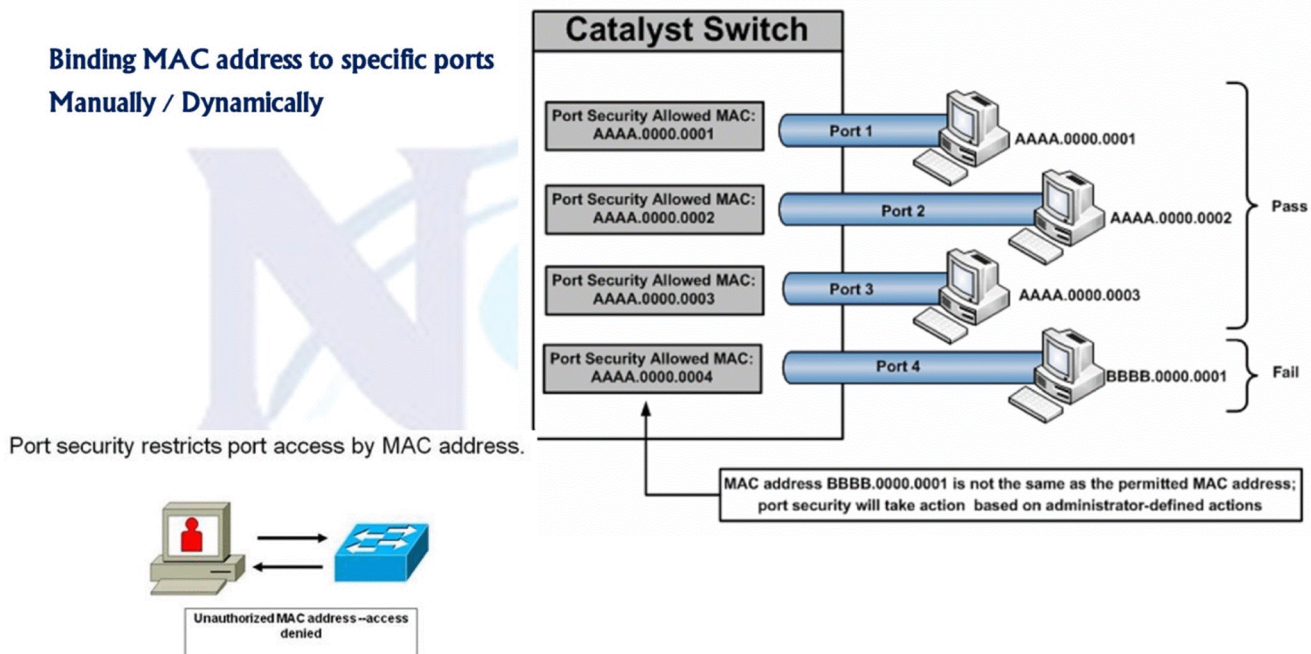


MAC Address Spoofing Attack



MAC Address Spoofing Attack (solution)

Binding MAC address to specific ports
Manually / Dynamically

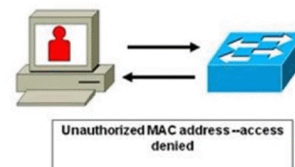


Port Security (Binding MAC addresses)

```
(config)# interface FastEthernet 0/10  
(config-if)# switchport mode access
```

Port security restricts port access by MAC address.

```
(config-if)# switchport port-security  
(config-if)# switchport port-security maximum value  
(config-if)# switchport port-security violation {protect | restrict | shutdown}
```



Manual Binding MAC addresses

```
(config-if)# switchport port-security mac-address mac-address
```

OR

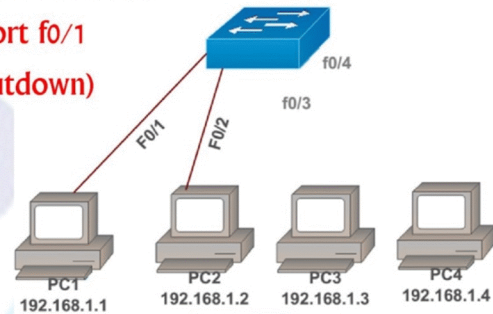
Dynamic Binding of Learned MAC Address

```
(config-if)# switchport port-security mac-address sticky
```


LAB : PORT-SECURITY

TASK :

- Configure Port-security on f0/1 with maximum mac-address limit to 2
- also the mac-address sticky option to bind the Mac on port f0/1
- if it exceeds it has to apply the default violation rule (shutdown)



```
Switch(config)#int f0/1
```

```
Switch(config-if)# switchport mode access
```

```
Switch(config-if)# switchport port-security
```

```
Switch(config-if)# switchport port-security maximum 2
```

```
Switch(config-if)#switchport port-security mac-address sticky
```

Verifying Port Security

Switch#sh mac-address-table

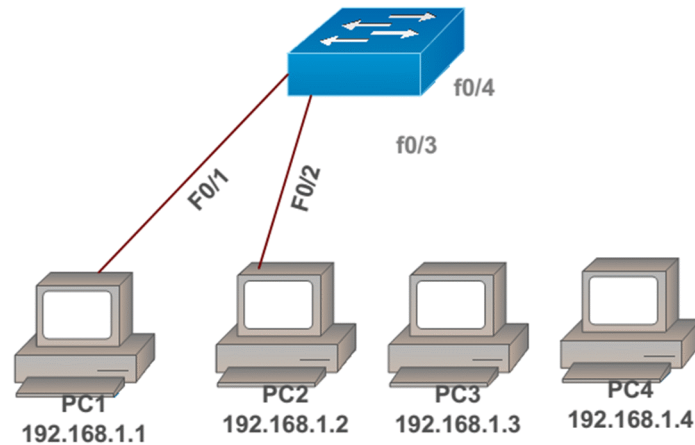
Mac Address Table

Vlan	Mac Address	Type	Ports
1	0001.974d.5308	DYNAMIC	Fa0/2
1	0005.5e88.800b	STATIC	Fa0/1
1	00e0.a325.1980	STATIC	Fa0/1

Switch#sh port-security

Secure Port	MaxSecureAddr (Count)	CurrentAddr (Count)	SecurityViolation (Count)	Security Action
Fa0/1	2	2	0	Shutdown

LAB : PORT-SECURITY



TASK :

- Configure Port-security on f0/1 with maximum mac-address limit to 2
- also the mac-address sticky option to bind the Mac on port f0/1
- if it exceeds it has to apply the default violation rule (shutdown)

```
Switch(config)#int f0/1
```

```
Switch(config-if)#switchport port-security
```

Command rejected: FastEthernet0/1 is a dynamic port.

```
Switch(config)# int f0/1
```

```
Switch(config-if)# switchport mode access
```

```
Switch(config-if)# switchport port-security
```

```
Switch(config-if)# switchport port-security maximum 2
```

```
Switch(config-if)#switchport port-security mac-address sticky
```

```
Switch(config-if)#end
```

```
Switch#sh running-config
```

Building configuration...

```
interface FastEthernet0/1
```

```
switchport mode access
```

```
switchport port-security
```

```
switchport port-security maximum 2
```

```
switchport port-security mac-address sticky
```

```
Switch#clear mac-address-table
```

```
Switch#sh mac-address-table
```

Mac Address Table

Vlan	Mac Address	Type	Ports
------	-------------	------	-------

Switch#sh port-security

Secure Port (Count)	MaxSecureAddr (Count)	CurrentAddr (Count)	SecurityViolation	Security Action
------------------------	--------------------------	------------------------	-------------------	-----------------

Fa0/1	2	0	0	Shutdown
-------	---	---	---	----------

TASK :

- Configure F0/1 port to use port-fast to ensure that it comes to forwarding immediately.
- Connect PC(192.168.1.1) on f0/1 and generate traffic by using ping to other devices in the LAN.
- Try connecting another device and generate traffic to test Port-security violation rule.

Switch(config)#int f0/1

Switch(config-if)#spanning-tree portfast

Switch(config-if)#end

NOTE :

In order to test and verify we are using port-fast (portfast is not mandatory to configure port-security) . here we are using to speed up the access ports convergence time.

PC>ipconfig

FastEthernet0 Connection:(default port)

Link-local IPv6 Address.....: ::

IP Address.....: 192.168.1.1

Subnet Mask.....: 255.255.255.0

Default Gateway.....: 192.168.1.100

PC>ping 192.168.1.2

Pinging 192.168.1.2 with 32 bytes of data:

Reply from 192.168.1.2: bytes=32 time=0ms TTL=128

Reply from 192.168.1.2: bytes=32 time=0ms TTL=128

Reply from 192.168.1.2: bytes=32 time=0ms TTL=128

Reply from 192.168.1.2: bytes=32 time=0ms TTL=128

Ping statistics for 192.168.1.2:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

Switch#sh mac-address-table

Mac Address Table

Vlan	Mac Address	Type	Ports
1	0001.974d.5308	DYNAMIC	Fa0/2
1	0005.5e88.800b	STATIC	Fa0/1

Switch#sh run

Building configuration...

spanning-tree mode pvst

!

interface FastEthernet0/1

switchport mode access

switchport port-security

switchport port-security maximum 2

switchport port-security mac-address sticky

switchport port-security mac-address sticky 0005.5E88.800B

spanning-tree portfast

Switch#sh port-security

Secure Port	MaxSecureAddr (Count)	CurrentAddr (Count)	SecurityViolation (Count)	Security Action
-------------	--------------------------	------------------------	------------------------------	-----------------

Fa0/1	2	1	0	Shutdown
-------	---	---	---	----------

Sticky will automatically bind the mac-address learned on f0/1 port.

maximum mac-address option will not allow to learn more than one mac-address as per our configuration here.

TASK :

- Remove the PC connected on f0/1 and try connecting another PC (here 192.168.1.3) and generate traffic from new PC connected.

Switch#sh running-config

interface FastEthernet0/1

switchport mode access

switchport port-security

switchport port-security maximum 2

switchport port-security mac-address sticky

switchport port-security mac-address sticky 0005.5E88.800B

switchport port-security mac-address sticky 00E0.A325.1980

spanning-tree portfast

Switch#sh port-security

Secure Port	MaxSecureAddr (Count)	CurrentAddr (Count)	SecurityViolation (Count)	Security Action
Fa0/1	2	2	0	Shutdown

TASK :

- Connect PC4 (192.168.1.4) to f0/1 port by removing 192.168.1.3
- Verify as per the configuration the f0/1 port should go in to err-disable state.

PC>ipconfig

FastEthernet0 Connection:(default port)

Link-local IPv6 Address.....: FE80::20C:CFFF:FEE2:3946
IP Address.....: 192.168.1.4
Subnet Mask.....: 255.255.255.0
Default Gateway.....: 0.0.0.0

PC>ping 192.168.1.2

Pinging 192.168.1.2 with 32 bytes of data:

Request timed out.

Request timed out.

Request timed out.

Request timed out.

Ping statistics for 192.168.1.2:

Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),

Switch#sh ip int brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/1	unassigned	YES	manual	down	down

TASK :

- Reconnect PC1 (192.168.1.1) back on f0/1 port.
- and ensure that port comes back to up state and should be reach other devices in the LAN.

Switch#sh ip int brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/1	unassigned	YES	manual	down	down

Switch(config)#int f0/1

Switch(config-if)#shutdown

Switch(config-if)#no shutdown

```
Switch(config-if)#end
```

```
Switch#sh ip int brief
```

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/1	unassigned	YES	manual	up	up

```
Switch#sh running-config
```

```
interface FastEthernet0/1
switchport mode access
switchport port-security
switchport port-security maximum 2
switchport port-security mac-address sticky
switchport port-security mac-address sticky 0005.5E88.800B
switchport port-security mac-address sticky 00E0.A325.1980
spanning-tree portfast
```

```
Switch#sh mac-address-table
```

Mac Address Table

Vlan	Mac Address	Type	Ports
1	0001.974d.5308	DYNAMIC	Fa0/2
1	0005.5e88.800b	STATIC	Fa0/1
1	00e0.a325.1980	STATIC	Fa0/1

On f0/1 there is MAC biniding done with PC1 and PC2 Mac-address. if anyother device is connected on f0/1 it will put the port in to shutdown state.

TASK: Configure the Violation rule to protect mode instead of shutdown

```
Switch(config)#int f0/1
```

```
Switch(config-if)#switchport port-security violation ?
```

protect Security violation protect mode

restrict Security violation restrict mode

shutdown Security violation shutdown mode

```
Switch(config-if)#switchport port-security violation protect
```

```
Switch(config-if)#end
```

```
Switch#sh running-config
```

```
interface FastEthernet0/1
switchport mode access
```

```

switchport port-security
switchport port-security maximum 2
switchport port-security mac-address sticky
switchport port-security violation protect
switchport port-security mac-address sticky 0005.5E88.800B
switchport port-security mac-address sticky 00E0.A325.1980
spanning-tree portfast

```

!

To test connect PC3 to f0/1 and try generating traffic to other devices in the LAN,

Switch#sh ip int brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/1	unassigned	YES	manual	up	up

Switch#show port-security

Secure Port	MaxSecureAddr (Count)	CurrentAddr (Count)	SecurityViolation (Count)	Security Action
Fa0/1	2	2	0	Protect

PC>ipconfig

FastEthernet0 Connection:(default port)

Link-local IPv6 Address.....: FE80::20C:CFFF:FEE2:3946
 IP Address.....: 192.168.1.4
 Subnet Mask.....: 255.255.255.0
 Default Gateway.....: 0.0.0.0

PC>ping 192.168.1.2

Pinging 192.168.1.2 with 32 bytes of data:

Request timed out.
 Request timed out.
 Request timed out.
 Request timed out.

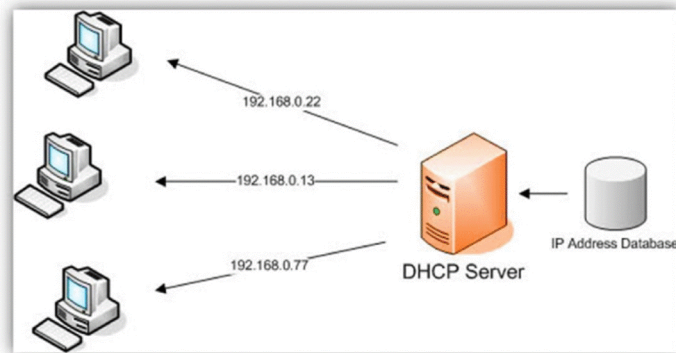
Ping statistics for 192.168.1.2:

Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),

What is DHCP ?

allows a server to dynamically distribute IP addressing and configuration information to clients.

- ▶ IP Address
- ▶ Subnet Mask
- ▶ Default Gateway
- ▶ DNS server

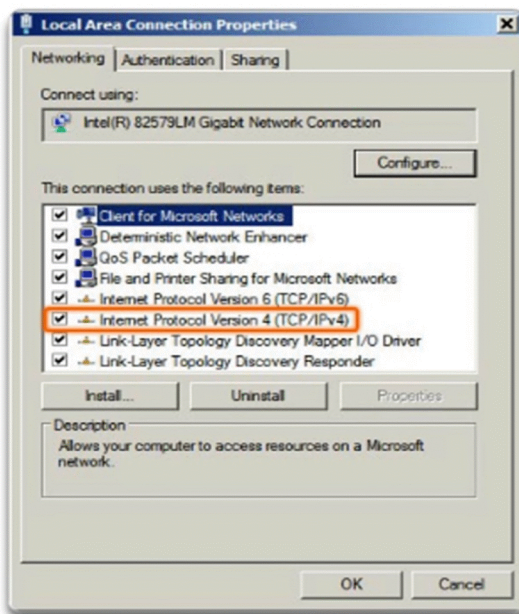


Advantages :

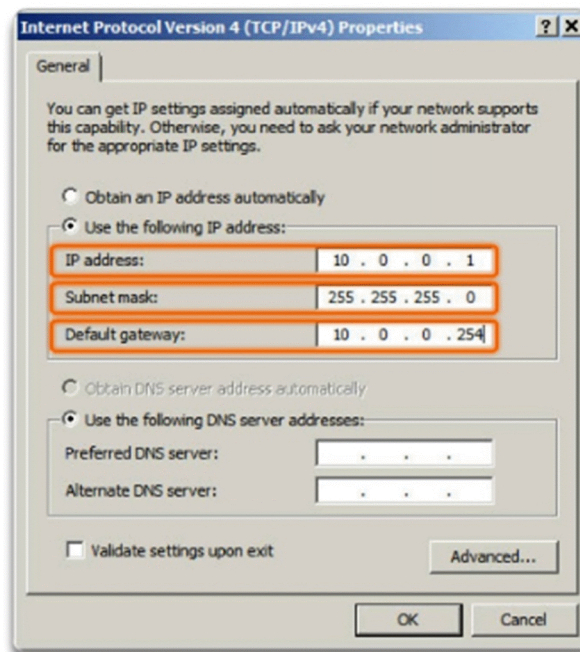
- ▶ Centralized network client configuration
- ▶ easier IP address management
- ▶ Reduced network administration.
- ▶ large network support

Assigning a Static IPv4 Address to a Host

LAN Interface Properties

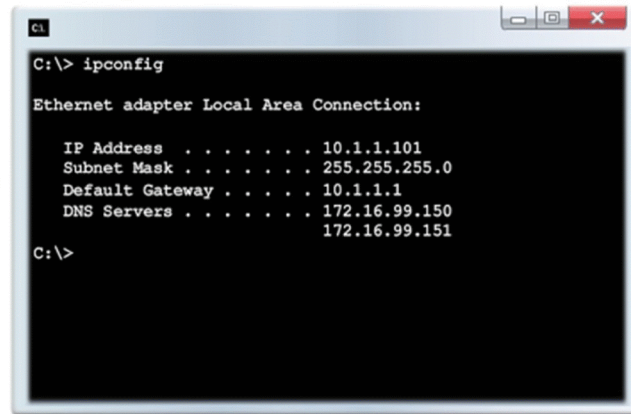
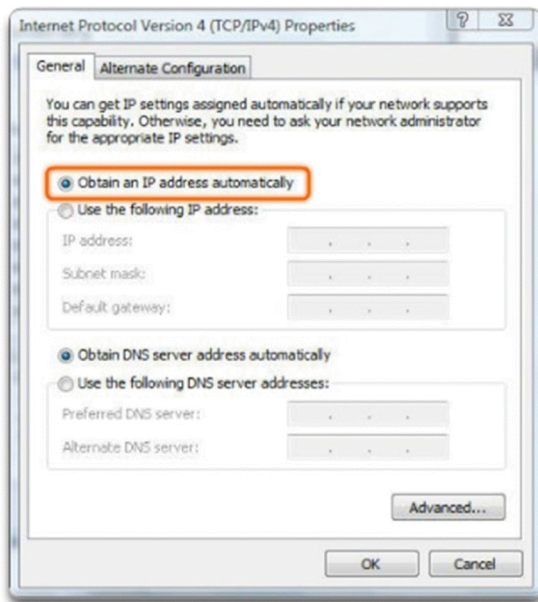


Configuring a Static IPv4 Address



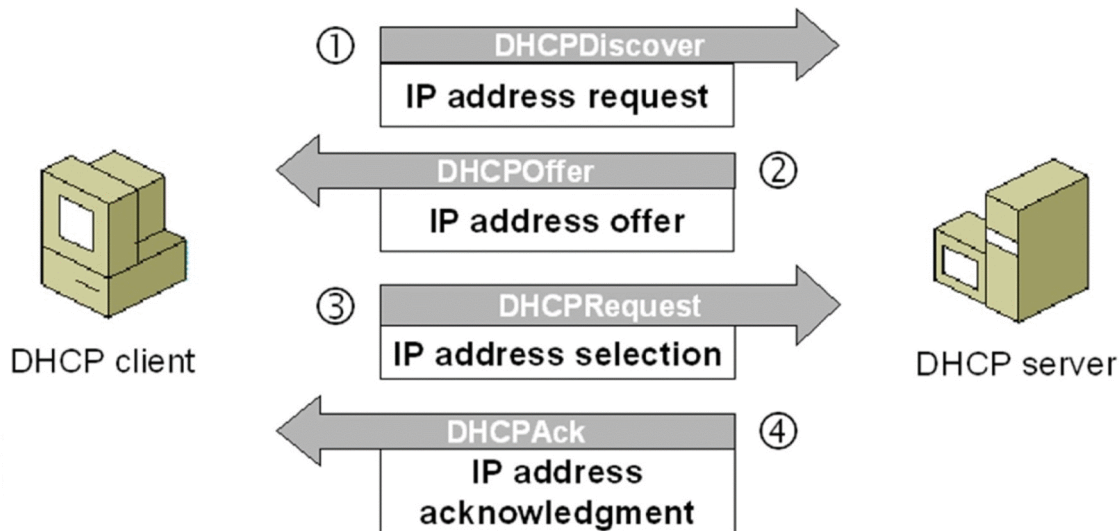
Assigning a Dynamic IPv4 Address to a Host

Assigning a Dynamic IPv4 Address

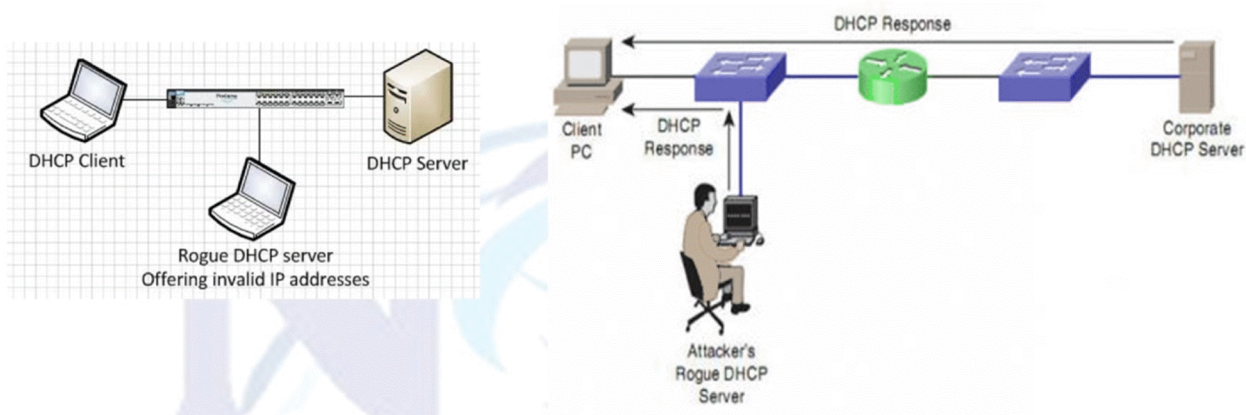


DHCP - preferred method of "leasing" IPv4 addresses to hosts on large networks, reduces the burden on network support staff and virtually eliminates entry errors

DHCP Process



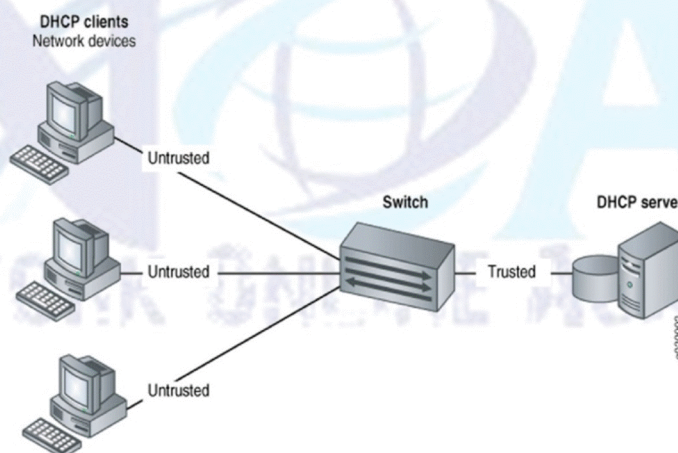
DHCP spoofing Attack



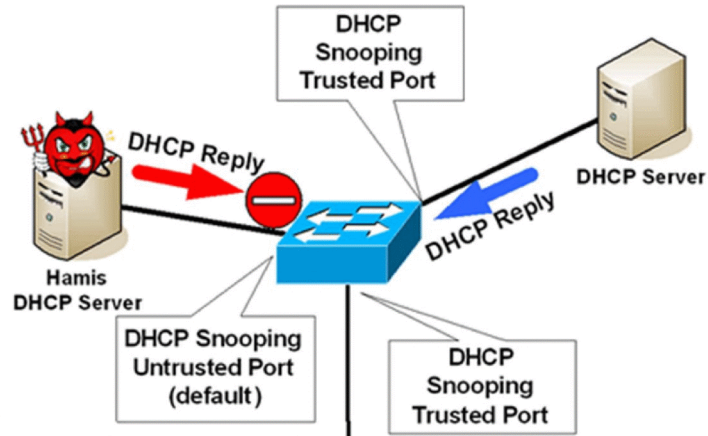
- Attacker activates DHCP server on VLAN.
- Attacker replies to valid client DHCP requests.
- Attacker provides wrong network information (leads to Dos attack)
- Attacker assigns IP configuration information that establishes rogue device as client default gateway.
- Attacker establishes “man-in-the-middle” attack.

DHCP Snooping

- DHCP snooping allows the Configuration of ports as trusted or untrusted.
- Untrusted ports cannot process DHCP replies.
- Configure DHCP snooping on uplinks to a DHCP server.
- Do not configure DHCP snooping on client ports.



DHCP Snooping Configuration



```
Switch(config)# ip dhcp snooping
Switch(config)# ip dhcp snooping vlan number [number]

Switch(config)# interface f0/1
Switch(config-if)# ip dhcp snooping trust
```

Verifying DHCP Snooping

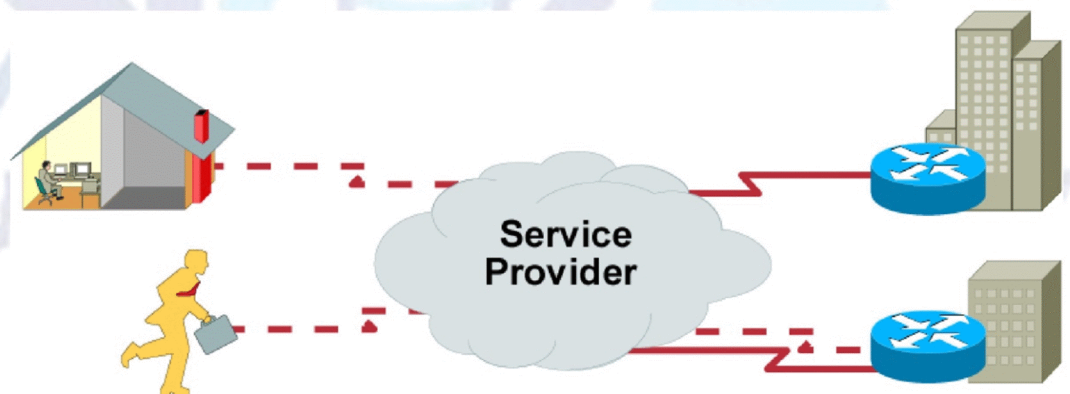
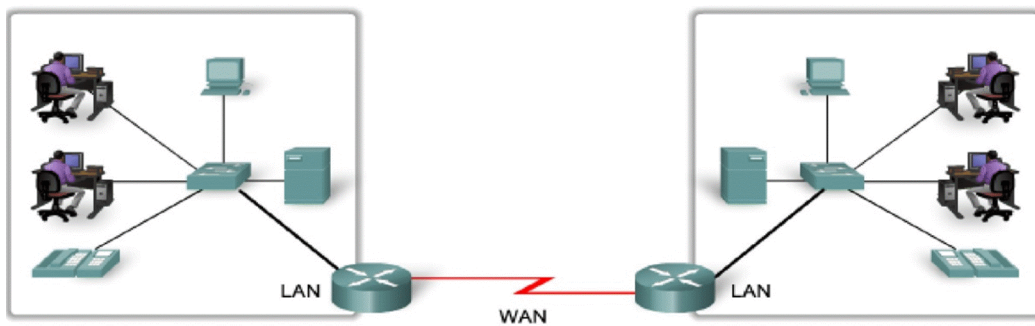
```
Switch# show ip dhcp snooping
```

Verifies the DHCP snooping configuration

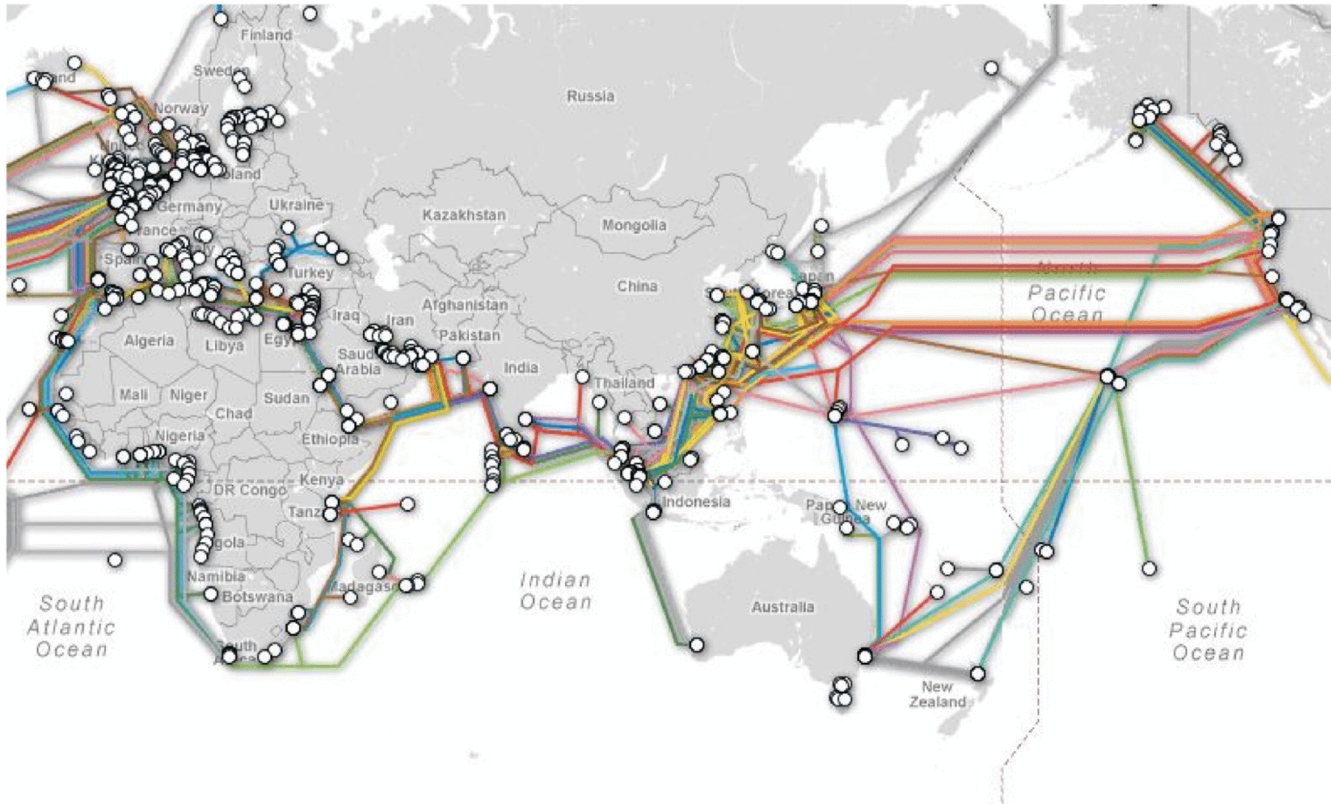
```
Switch# show ip dhcp snooping
Switch DHCP snooping is enabled
DHCP Snooping is configured on the following VLANs:
 10 30-40 100 200-220
Insertion of option 82 information is enabled.
Interface      Trusted      Rate limit (pps)
-----
FastEthernet2/1  yes         none
FastEthernet2/2  yes         none
FastEthernet3/1  no          20
```

WAN Technologies

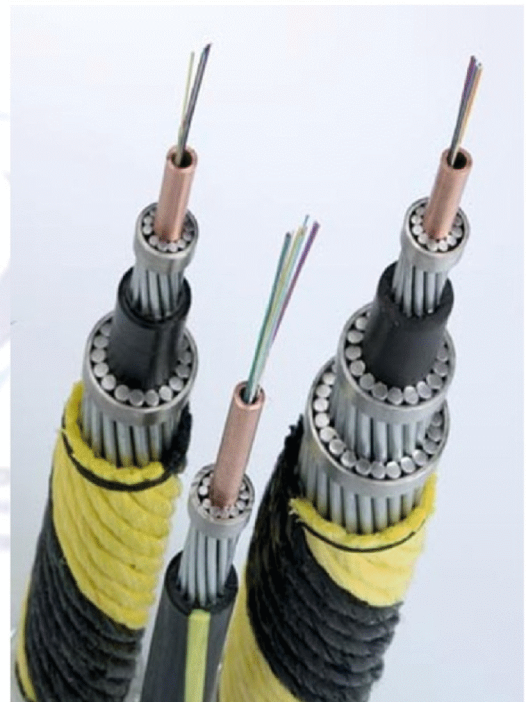
Leased lines, Frame relay, MPLS, Metro-ethernet, VPN, Cable, DSL



Sub-marine Cabling



Sub-marine Cabling



Sub-marine Cabling



Service providers in India

There are 4 major players for International bandwidth in India.
VSNL/Tata, Bharti Airtel, Reliance and BSNL.

India connects to the world through 4 cities
Chennai, Mumbai, Cochin and Tuticorin.

SUB-MARINE CABLING:

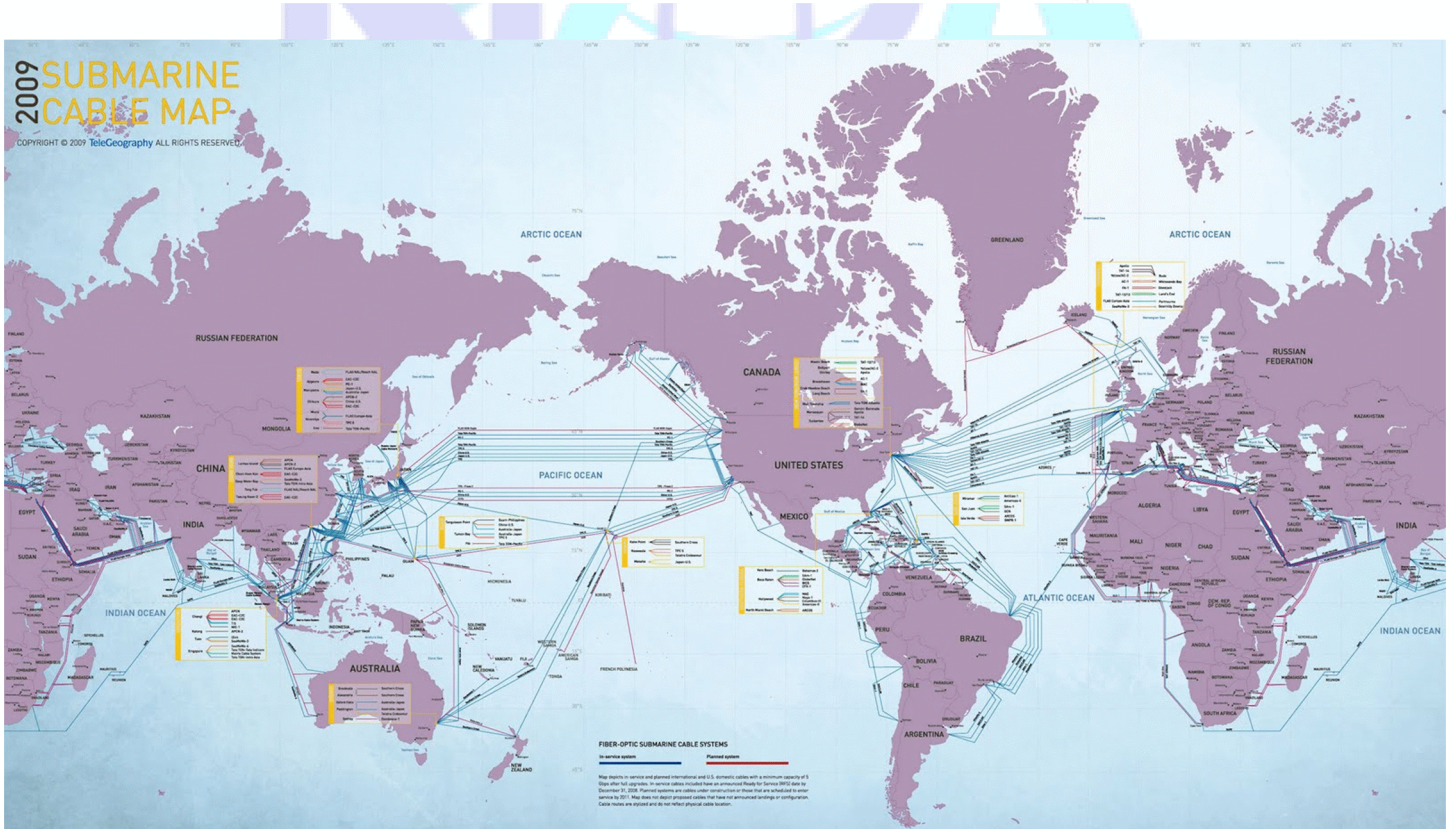
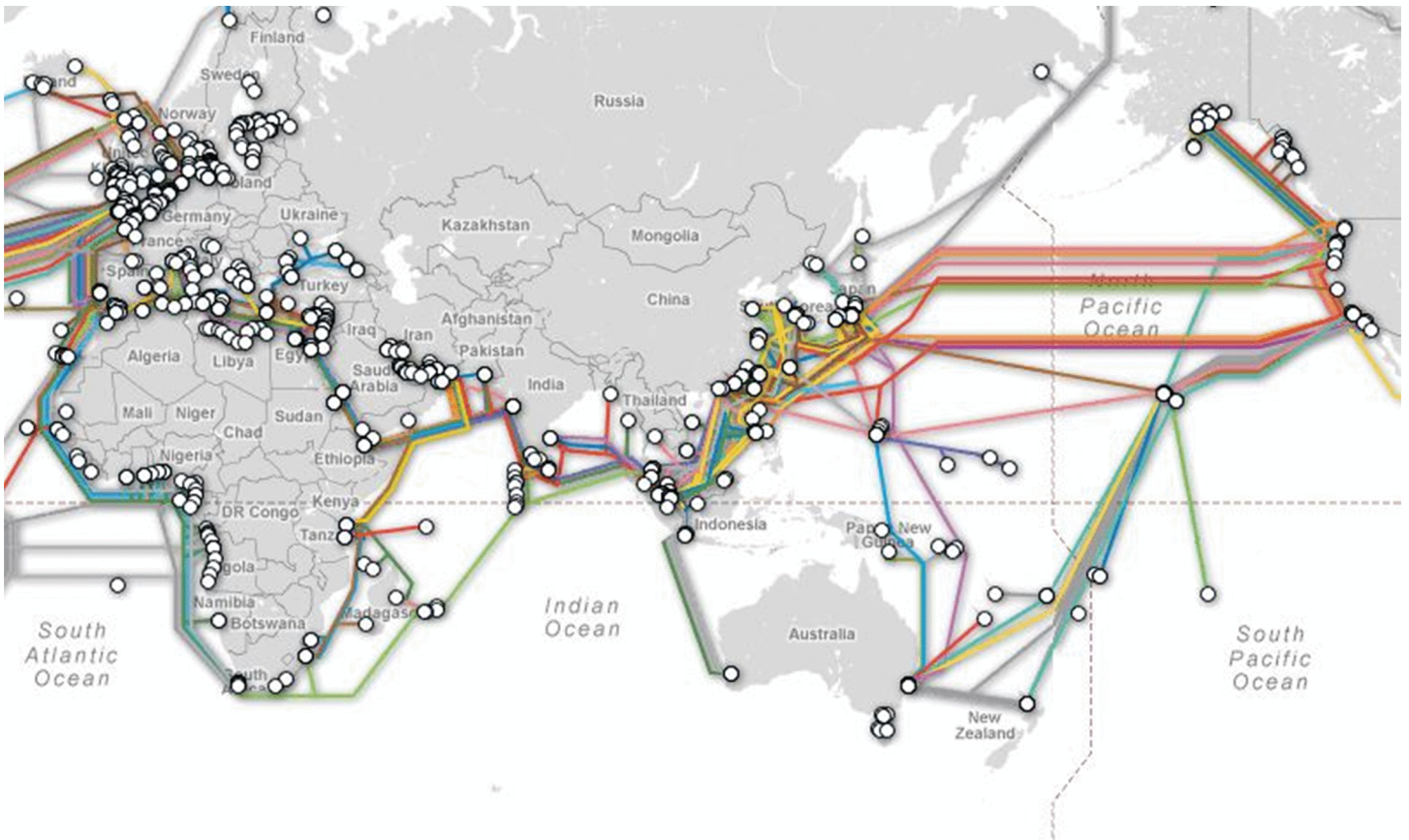
There are 4 major players for International bandwidth in India. VSNL/Tata, Bharti Airtel, Reliance and BSNL

India connects to the world through 4 cities Chennai, Mumbai, Cochin and Tuticorin.

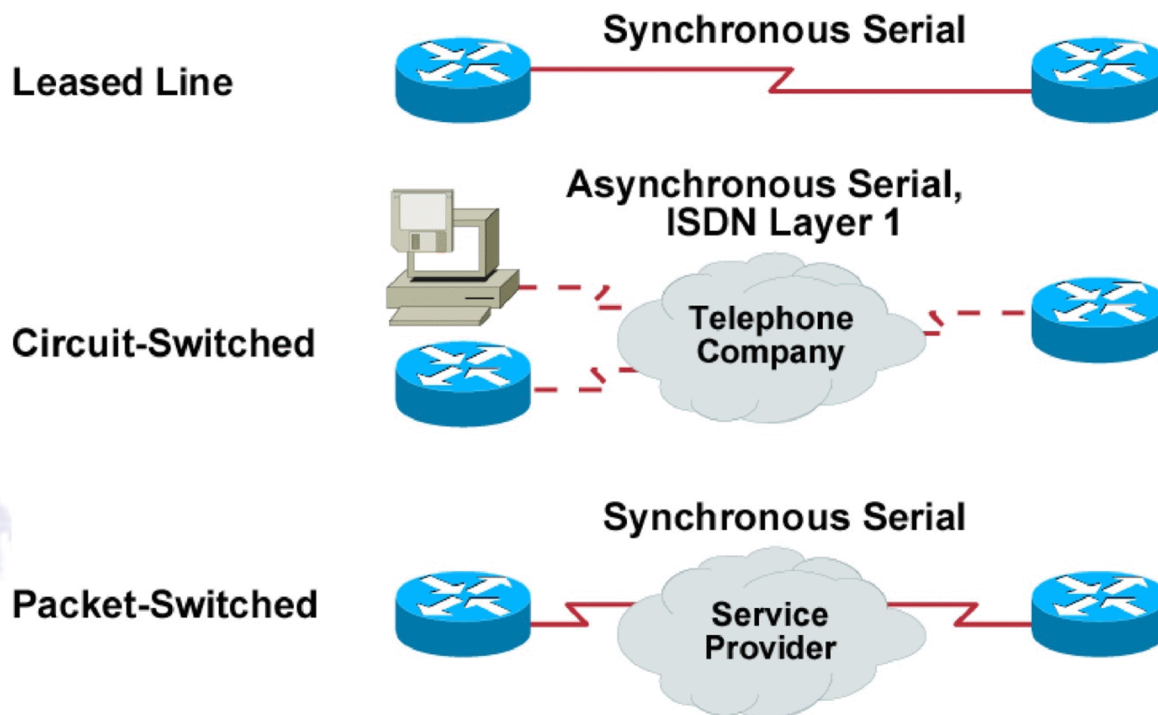
Here are the 8 submarine cables connecting India with details:

The 8 submarine cables connecting India to the world:

1. **SMW3w** : Stands for South East Asia – Middle East – Western Europe this cable connects Western Europe, Middle East and South east Asia. There are a total of 39 landing points through the cable's journey and it touches India at **Mumbai** first and connects the rest of Asia through Cochin. The landing station in **Mumbai** is owned by VSNL/Tata.
2. **SMW4** : Stands for South East Asia – Middle East – Western Europe, this cable connects Western Europe, Middle East and South east Asia. It has around 17 landing points and touches India in Mumbai and Chennai. Landing station in Mumbai is owned by VSNL/Tata and landing station in Chennai is owned by Bharti Airtel.
3. **SAFE** : South Africa Far East Cable. This cable comes from Melkbosstrand in South Africa, linking Durban, Mauritius on the way to Cochin, India. Landing station in Cochin is owned by VSNL/Tata.
4. **FLAG** : Stands for Fiber Optic Link Around the Globe. This cable runs through the Suez canal connecting middle east and touches India at Mumbai. The cable network is owned by FLAG Telecom which is bought by Reliance and is now a Reliance company. The landing station in Mumbai is owned by VSNL/Tata. From Mumbai the cable goes to south east Asia.
5. **i2i** : Airtel Singtel joint venture company is responsible for this 3100 km long cable from Singapore to Chennai. The landing station is in Chennai. From Singapore it will connect to SEA-ME-WE 3 and APCN
6. **TIC** : Following the same route as i2i, TIC stands for Tata Indicom India Singapore Cable. It connects Chennai and Singapore. TIC is owned by VSNL with the landing station in Chennai. In Singapore the landing station is in Changi. The cable is 3175 km long.
7. **Falcon** : Europe-Middle East- India cable with landing station in Mumbai. The cable and the landing station is owned by Reliance.
8. **Indo-Sri Lanka Cable** : Landing station is owned by BSNL and this cable connects Tuticorin and Colombo, Sri Lanka.



WAN Connection Types

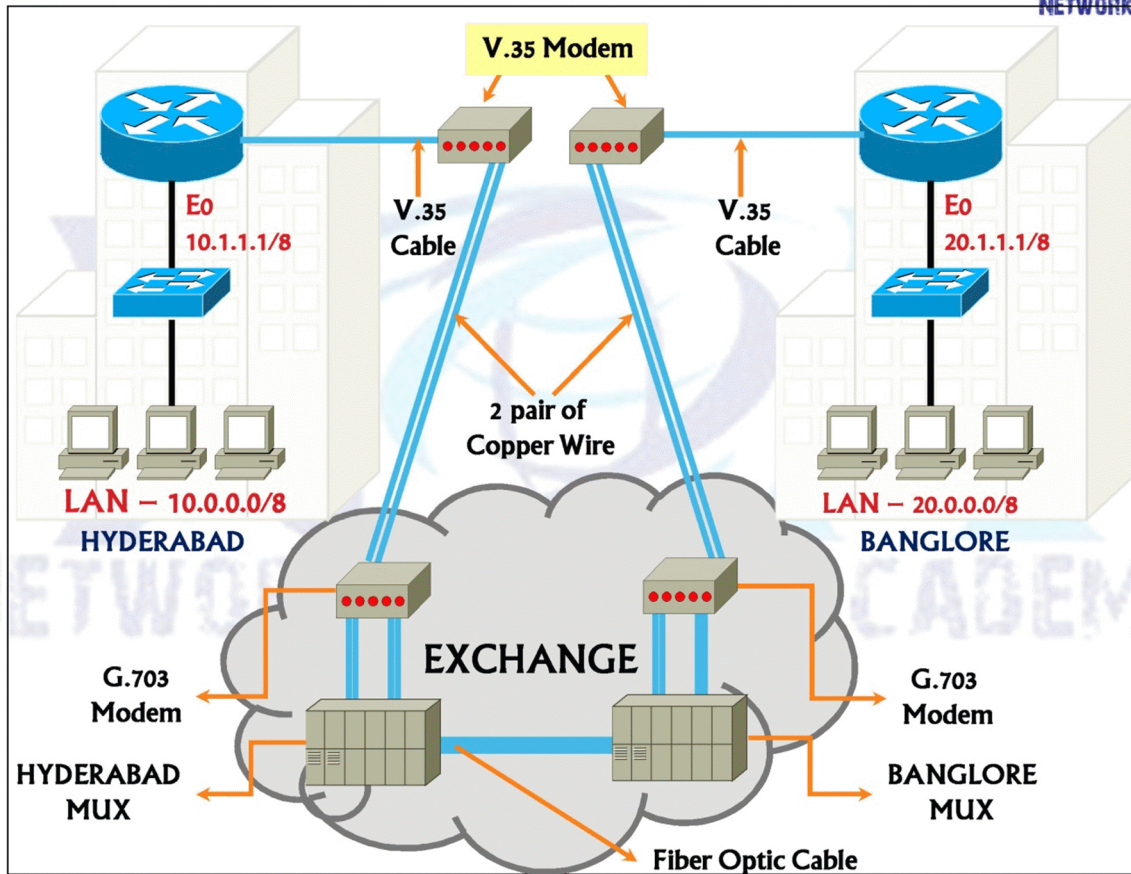


Leased Lines

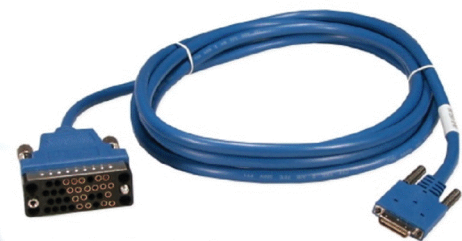
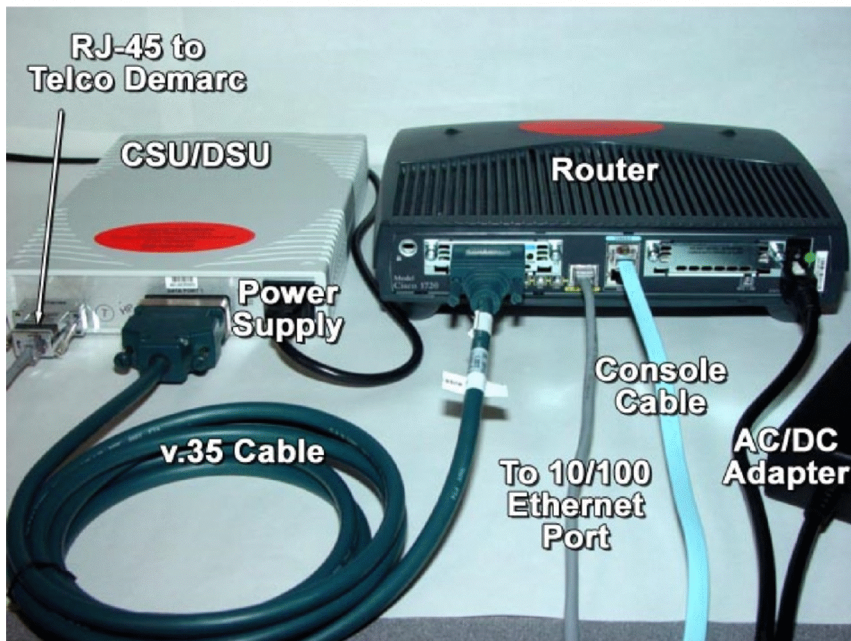
- Permanent connection for the destination
- Used for short or long distance
- Bandwidth is fixed
- Availability is 24/7
- Charges are fixed whether used or not.
- Uses analog circuits
- Always same path is used for destination
- Example is Leased Line



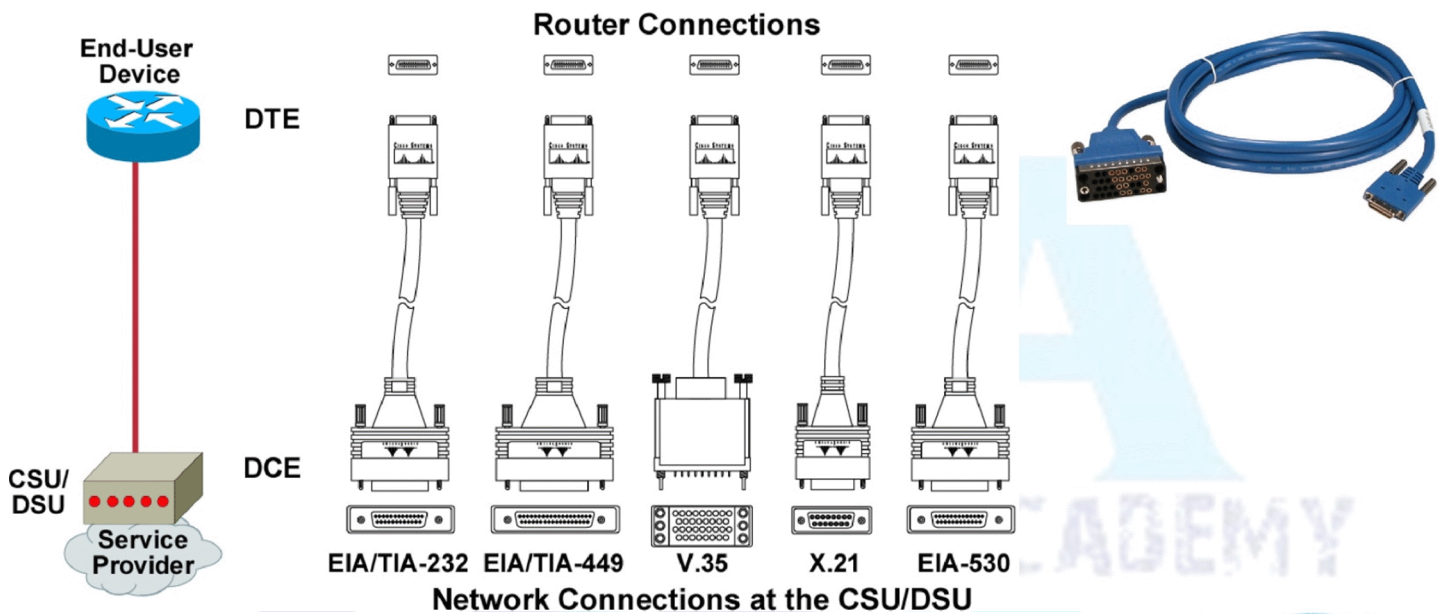
Leased Lines



V.35 modems & Cable



Serial Point-to-Point Connections

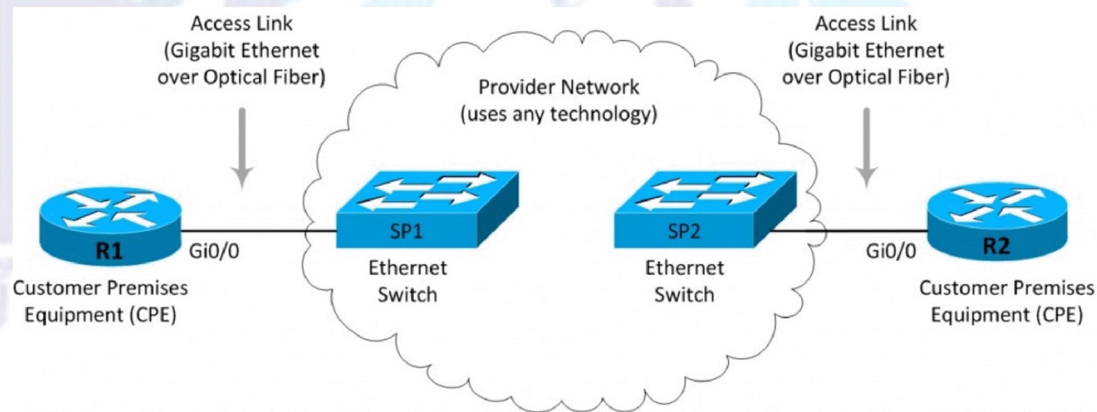


Modern WAN Connections

- ▶ Metro Ethernet
- ▶ MPLS
- ▶ Virtual Private Network (VPN)
- ▶ DSL
- ▶ Cable
- ▶ VSAT

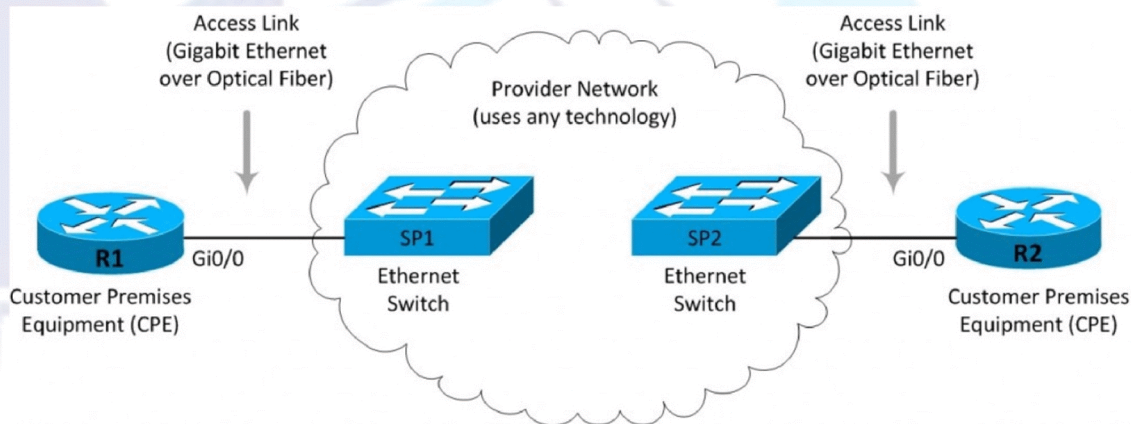
Metro Ethernet lines

- Initially Ethernet was only restricted to LAN (distance limits)
- Use fiber Standards support for longer distances.
- Overcome both speed and Distance limits.
- Service providers started using Ethernet in WAN.



Advantages

- Support high Speeds up to 100 Mbps or 1 Gbps (Frame relay upto 44 Mbps)
- Customer end uses Ethernet Interface (Instead of Serial)



Metro Ethernet Switches

ME 3400 , ME3800X, ME 4900,



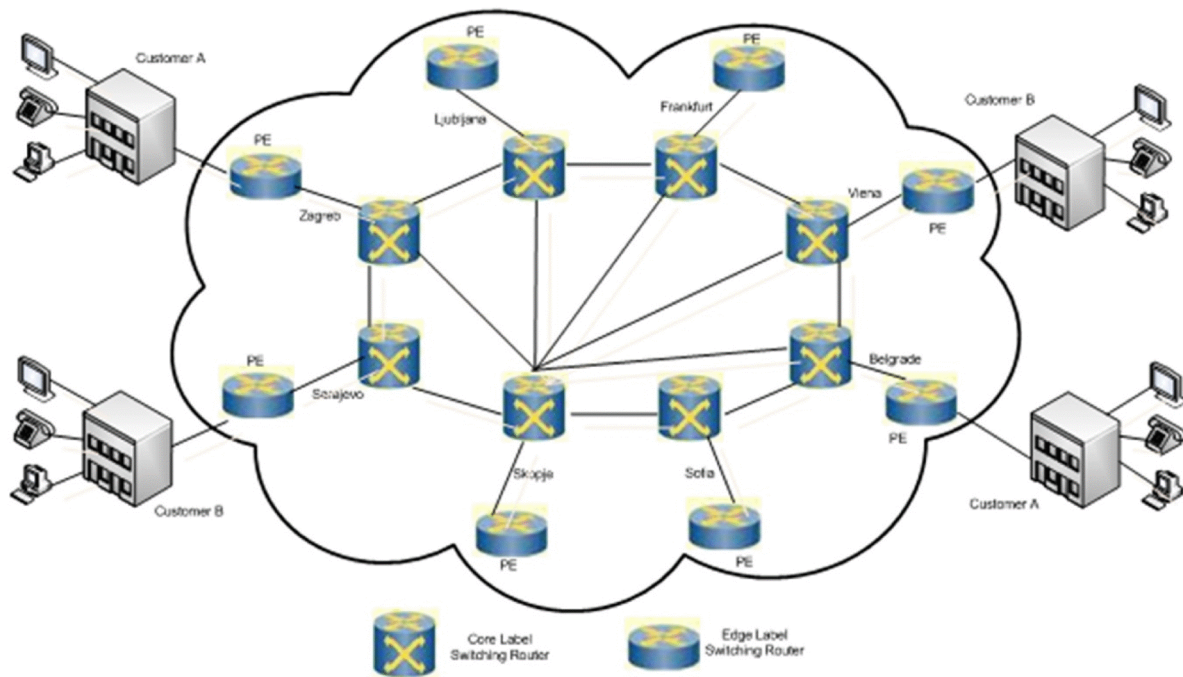
Multi Protocol Label Switching (MPLS)

- ▶ Works more like Frame Relay or Wan Ethernet.
- ▶ Uses “Labels” appended to packets for transport of data.
- ▶ Most common WAN technology used by service providers in today’s networks.
- ▶ MPLS packets can run on other layer 2 technologies such as ATM,FR, PPP, POS, Ethernet

Advantages :

- More scalable.

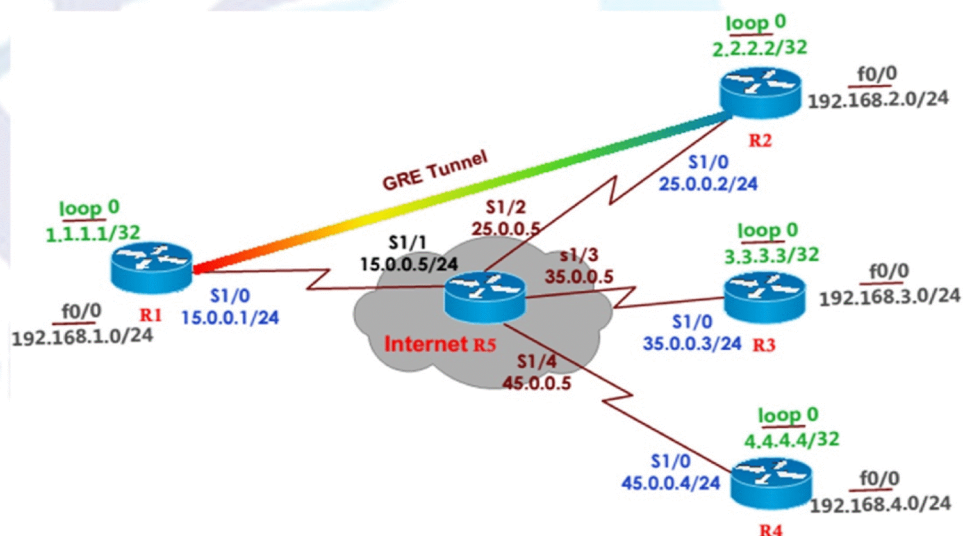
MPLS



NOA
NETWORK ONLINE ACADEMY

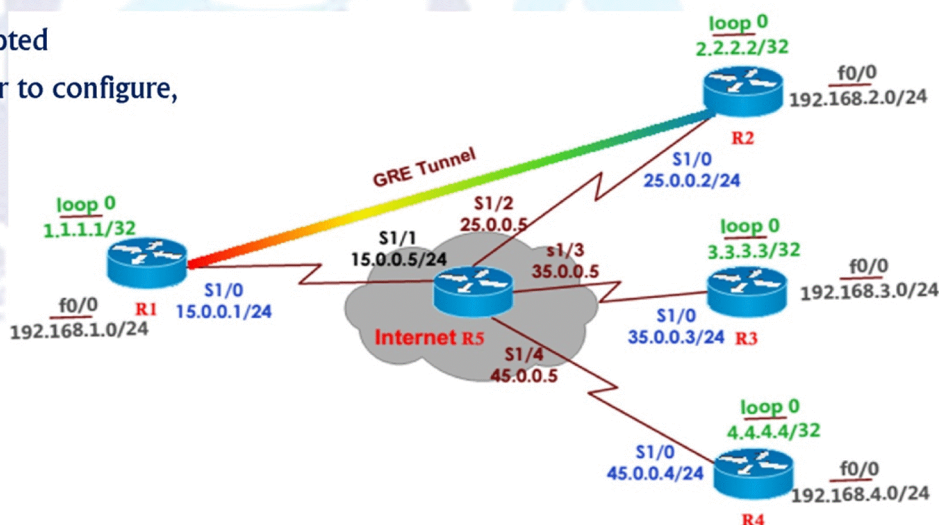
VPN over Internet

- ▶ Provider connectivity between two more sites over Internet
- ▶ Customer builds his own WAN over internet
- ▶ Cost effective solution.
- ▶ GRE , DMVPN , Ipsec VPN



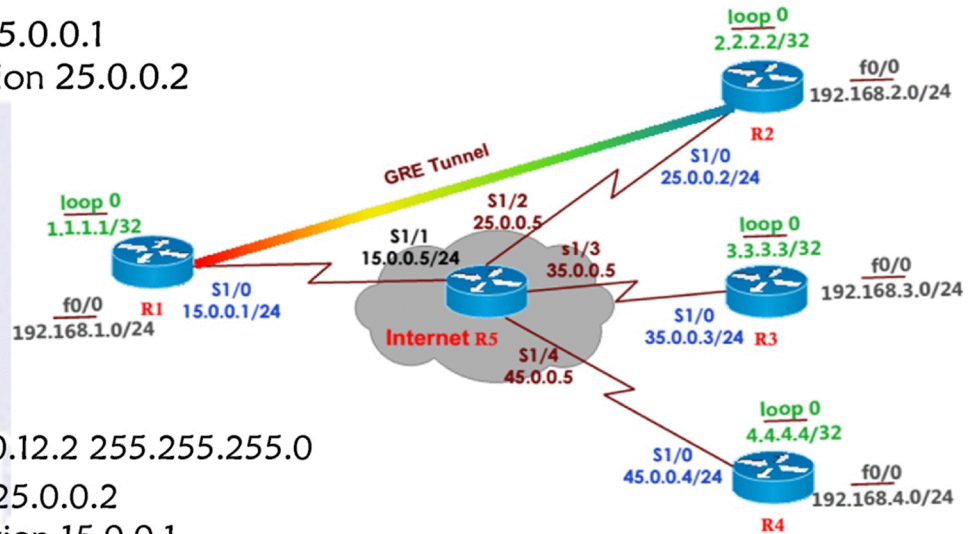
Generic Routing Encapsulation(GRE)

- ▶ Allow to have virtually point-to-point tunnel
- ▶ is used when packets need to be sent from one network to another over the Internet or an insecure network.
- ▶ tunneling protocol developed by Cisco
- ▶ Support encapsulation of a wide variety of network layer protocols inside point-to-point links.([multicast](#) and [IPv6](#))
- ▶ a GRE tunnel are not encrypted
- ▶ GRE tunnels are much easier to configure,



```
R1(config)#interface tunnel 12
R1(config-if)#ip address 10.0.12.1 255.255.255.0
R1(config-if)#tunnel source 15.0.0.1
R1(config-if)#tunnel destination 25.0.0.2
R1(config-if)#exit
```

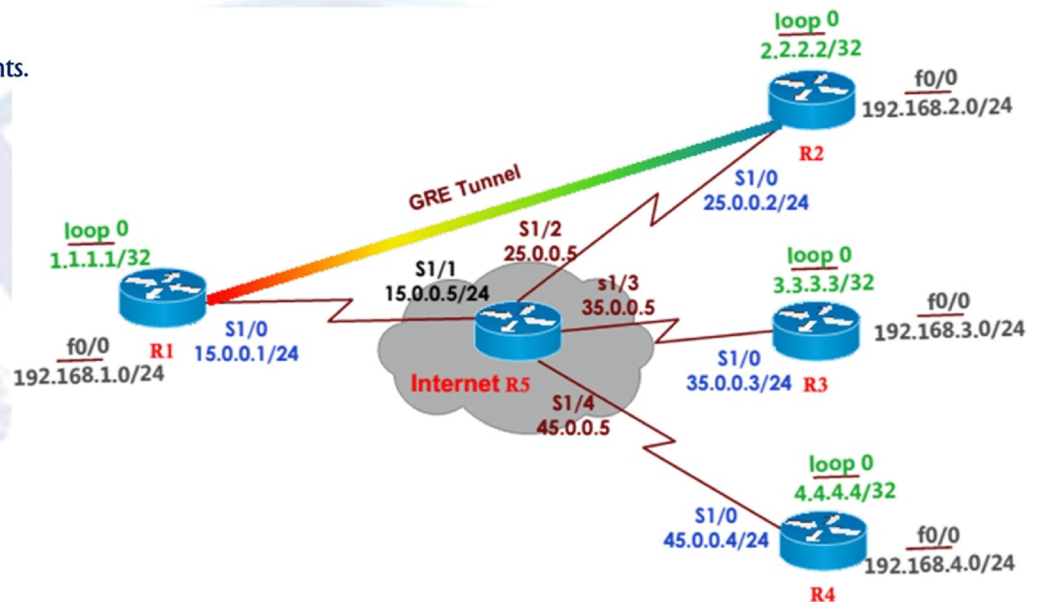
GRE Configuration



```
R2(config)# int tunnel 12
R2(config-if)# ip address 10.0.12.2 255.255.255.0
R2(config-if)# tunnel source 25.0.0.2
R2(config-if)# tunnel destination 15.0.0.1
R2(config-if)# exit
R2(config)#end
```

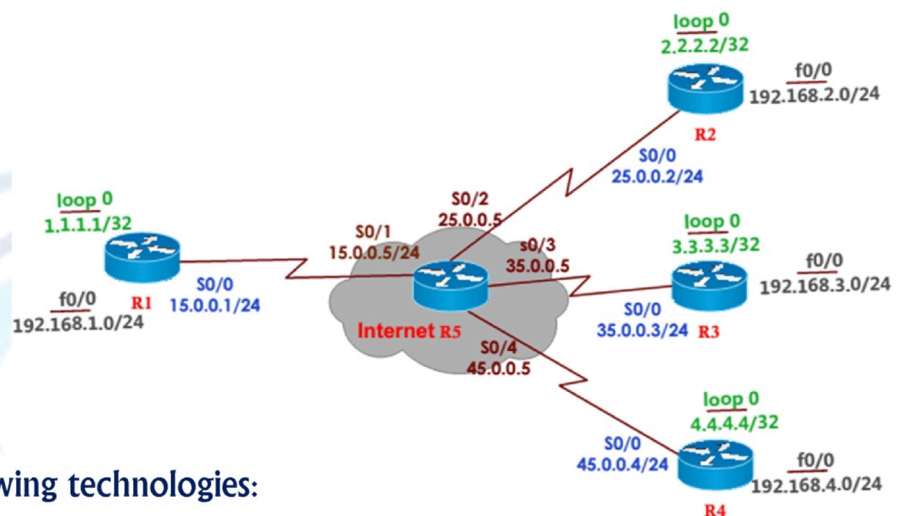
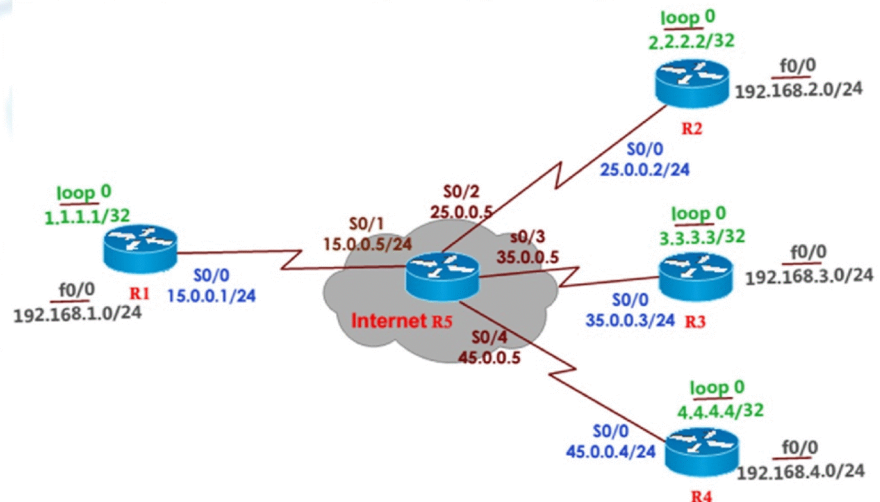
Drawbacks of GRE

- ▶ Classic GRE tunnel is point-to-point
- ▶ Manual tunnels
- ▶ Not scalable. (100 end points we need to build 99 tunnels)
- ▶ No encryption.
- ▶ Static IP on all end points.



Dynamic Multi Point VPN

- ▶ support point to multipoint. (uses mGRE)
- ▶ Automatic tunnels can be built between all the sites. (no need to manually configure)
- ▶ Spokes can have dynamic IP.
- ▶ keeping costs low, minimizing configuration complexity and increasing flexibility.

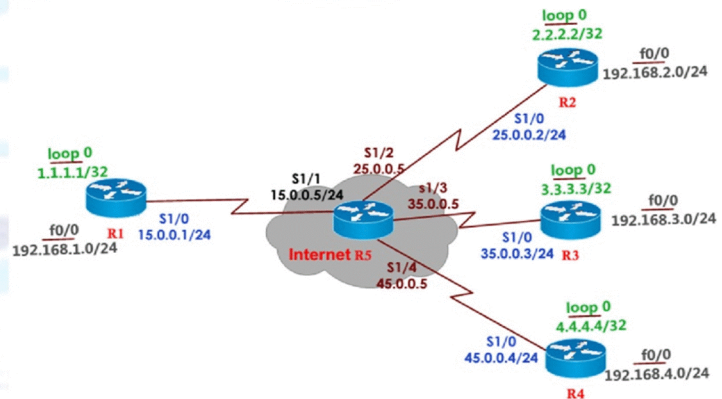


DMVPN is combination of the following technologies:

1. Multipoint GRE (mGRE)
2. Next-Hop Resolution Protocol (NHRP)
3. Dynamic Routing Protocol (EIGRP, RIP, OSPF, BGP)
4. Dynamic IPsec encryption

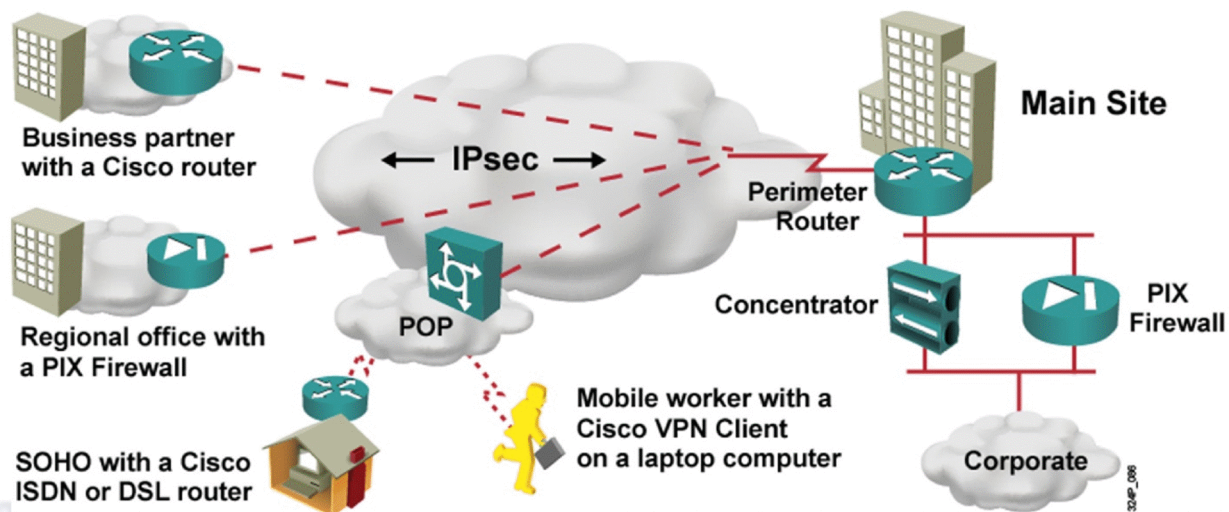
What Is IPsec?

- ▶ Internet Protocol Security (IPsec) is a set of protocols developed by the Internet Engineering Task Force (IETF).
- ▶ Allows two or more hosts to communicate in a secure manner by authenticating and encrypting each IP packet of a communication session.



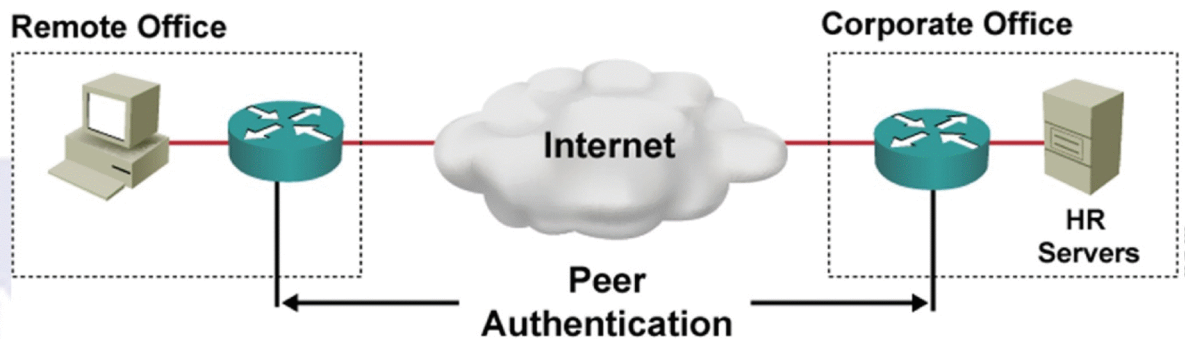
- Scales from small to very large networks
- Is available in Cisco IOS software version 11.3(T) and later
- included in PIX Firewall version 5.0 , ASA firewalls.

IPsec Security Features



IPsec is the only standard Layer 3 technology that provides:

- Confidentiality
- Data integrity
- Authentication
- Replay detection

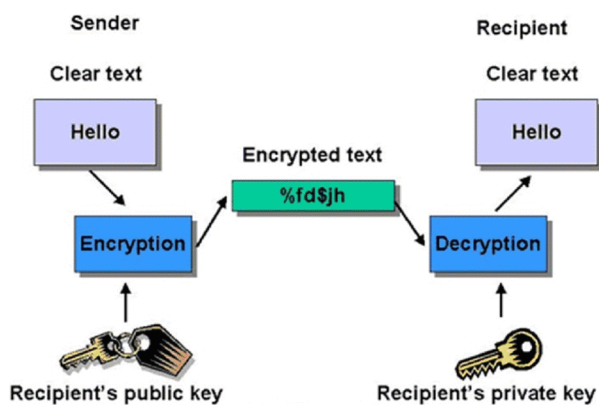


Remote peer & Data origin authentication

- provides confirmation about DataStream origin.

Data integrity (Hashing)

No one can modify the data (hashing algorithms)

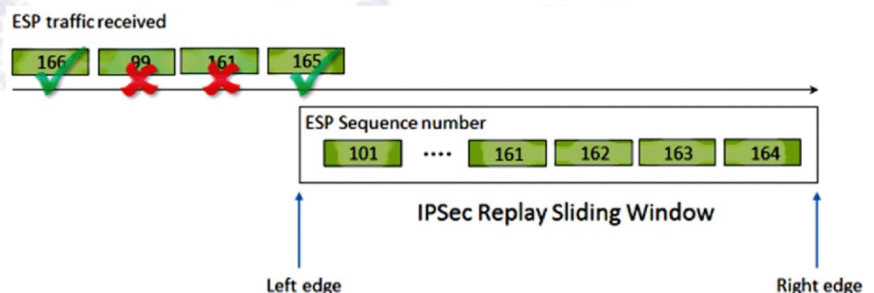


Data confidentiality (encryption)

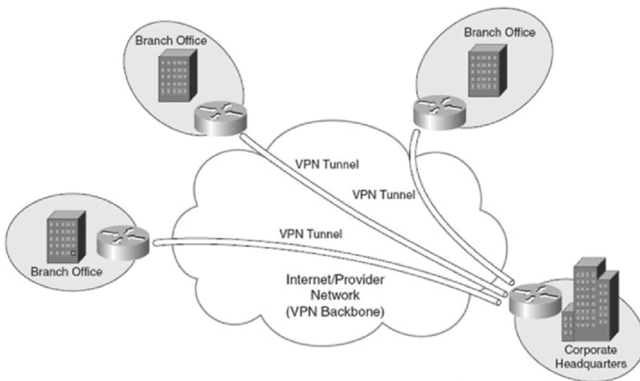
- ▶ means that the contents are not visible to third parties
- ▶ No snooping or wiretapping (using encryption)

Replay protection.

- ▶ Ensuring packet received only once
- ▶ security service where the receiver can reject old or duplicate packets in order to defeat replay attacks.



VPN types

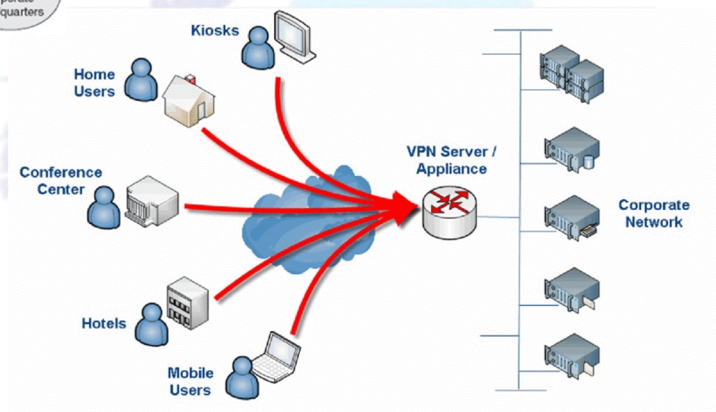


Site to Site VPN

allow a company to connect its remote sites to the corporate backbone securely Internet

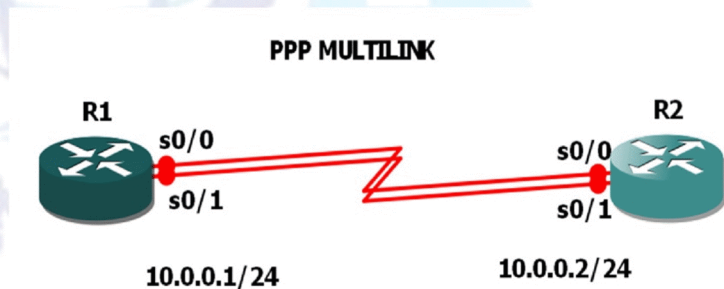
Remote site VPN

allow remote users to securely access the corporate network wherever and whenever they need to.



Multilink Point-to-Point Protocol

- ▶ MLP combines multiple physical links into a logical bundle called an MLP bundle.
- ▶ Used to aggregate multiple WAN links into one logical channel for the transport of traffic.
- ▶ It enables the load-balancing of traffic from different links and allows some level of redundancy in case of a line failure on a single link.
- ▶ Supports a maximum of ten member links per bundle.
- ▶ Member links can be any combination of T1/E1 or fractional T1s



LAB: PPP Multilink

```
Rx(config)# int s0/0
Rx(config-if)# no ip address
Rx(config-if)# encapsulation ppp
Rx(config-if)# ppp multilink
Rx(config-if)# ppp multilink group 1
Rx(config-if)# no shutdown
```

```
Rx(config)# int s0/1
Rx(config-if)# no ip address
Rx(config-if)# encapsulation ppp
Rx(config-if)# ppp multilink
Rx(config-if)# ppp multilink group 1
Rx(config-if)# no shutdown
```

```
Rx(config)#int multilink 1
Rx(config-if)#ppp multilink group 1
Rx(config-if)#ip address 10.0.0.2 255.0.0.0
Rx(config-if)#exit
```



LAB: Configuring a Multilink PPP



On both routers:

```
Rx(config)# int s0/0
Rx(config-if)# no ip add
Rx(config-if)# encapsulation ppp
Rx(config-if)# ppp multilink
Rx(config-if)# ppp multilink group 1
Rx(config-if)# no shutdown
Rx(config-if)# exit
```

```
Rx(config)# int s0/1
Rx(config-if)# no ip add
Rx(config-if)# encapsulation ppp
Rx(config-if)# ppp multilink
Rx(config-if)# ppp multilink group 1
Rx(config-if)# no shutdown
Rx(config-if)# exit
```

R2#sh ip int brief

Interface	IP-Address	OK?	Method	Status	Protocol
Serial0/0	unassigned	YES	manual	up	up
Serial0/1	unassigned	YES	unset	up	up
Serial0/2	unassigned	YES	unset	administratively down	down
Serial0/3	unassigned	YES	unset	administratively down	down

```
R2(config)#int multilink 1
R2(config-if)#ppp multilink group 1
R2(config-if)#ip address 10.0.0.2 255.0.0.0
R2(config-if)#exit
```

```
R1(config)# int multilink 1
R1(config-if)# ppp multilink
R1(config-if)# ppp multilink group 1
R1(config-if)# ip address 10.0.0.2 255.0.0.0
R1(config-if)#end
```

R1#ping 10.0.0.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.0.0.1, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 32/48/80 ms

R1#ping 10.0.0.2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.0.0.2, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 12/30/48 ms

R1#sh ip int brief

Interface	IP-Address	OK?	Method	Status	Protocol
Serial0/0	unassigned	YES	manual	up	up
Serial0/1	unassigned	YES	manual	administratively down	down
Serial0/2	unassigned	YES	unset	administratively down	down
Serial0/3	unassigned	YES	unset	administratively down	down
Multilink1	10.0.0.1	YES	manual	up	up

TASK: configure PPP chap authentication on R1/R2

R1(config)#username R2 password cisco

R1(config)#int multilink 1

R1(config-if)#encapsulation ppp

R1(config-if)#ppp authentication chap

R1(config-if)#exit

R2(config)#username R1 password cisco

R2(config)#int multilink 1

R2(config-if)#encapsulation ppp

R2(config-if)#ppp authentication chap

R2(config-if)#end

R2#ping 10.0.0.1

Type escape sequence to abort.

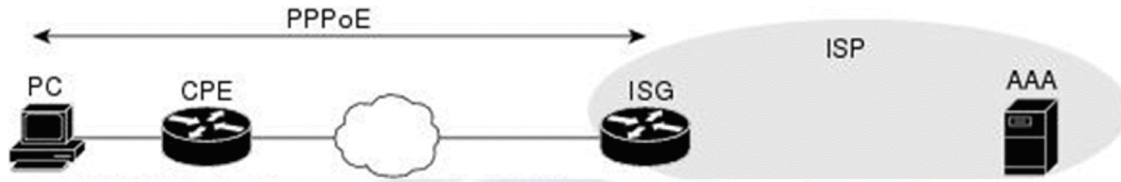
Sending 5, 100-byte ICMP Echos to 10.0.0.1, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 16/26/52 ms

R2#

PPPoE



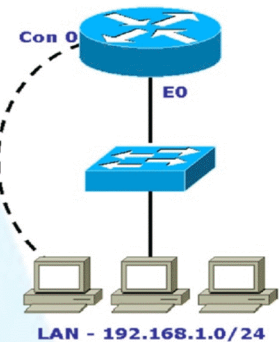
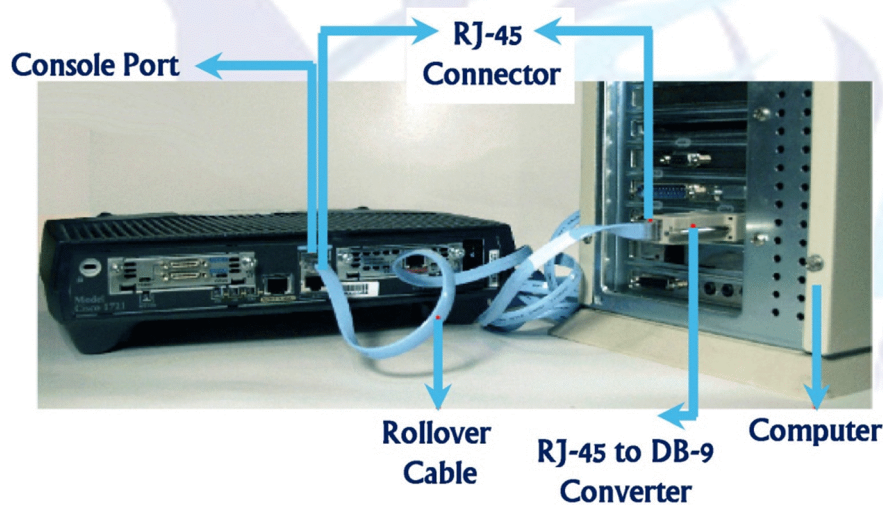
- ▶ PPPoE is configured as a point to point connection between two Ethernet ports.
 - ▶ For many cable and DSL internet connections, the ISPs inform their customers (subscribers) to set their router to receive IP address from them using username and password.
 - ▶ ISPs treat their subscriber's router as PPP client.
 - ▶ Allows virtual point to point connection over multipoint Ethernet network
-
- PPPoE is a protocol that is widely used by ISPs to provision digital subscriber line (DSL) high speed Internet services, of which the most popular service is ADSL.
 - Service providers can use the same authentication server for both PPP and PPPoE sessions, resulting in a cost savings.
 - PPPoE uses standard methods of encryption, authentication, and compression specified by PPP.

Password Reverting & backup Restore

Routing & Switching

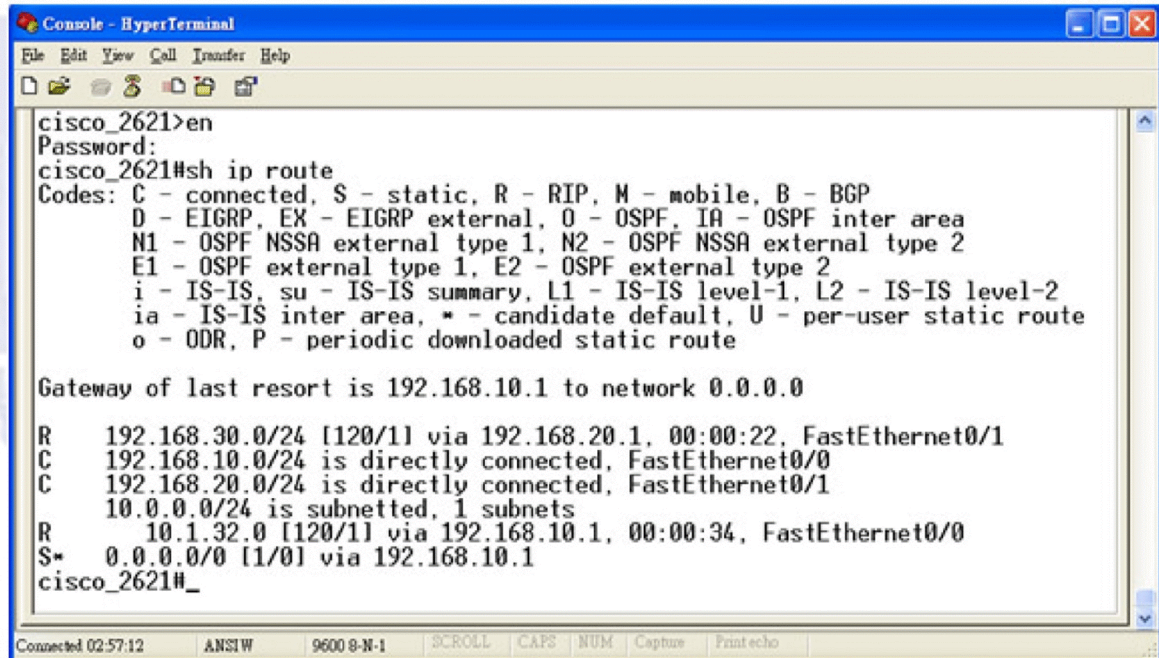
Password Reverting on Cisco Routers

console connection



Open hyper-terminal /putty software for console access.

HyperTerminal for console access



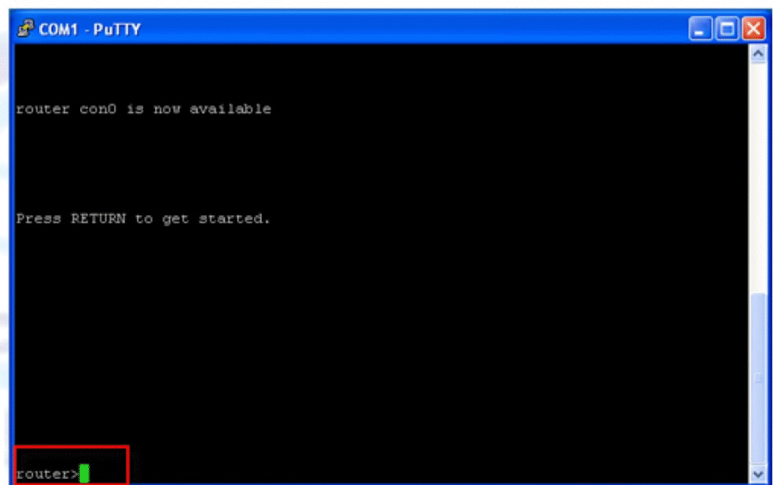
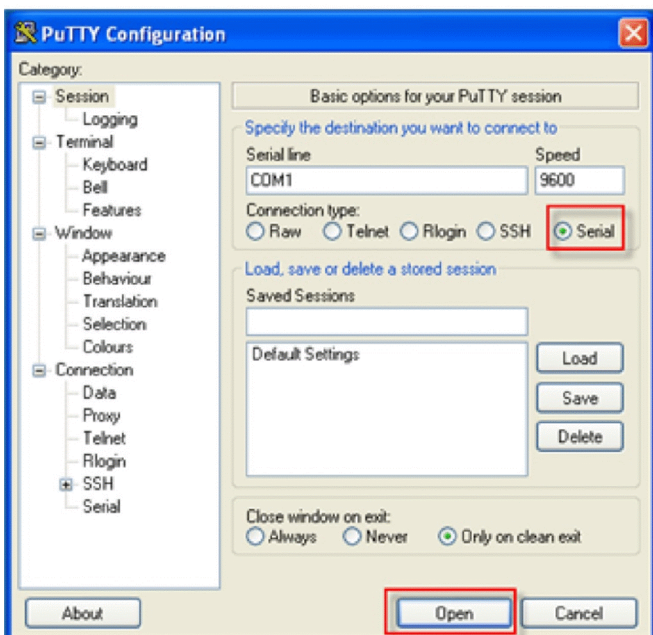
```

cisco_2621>en
Password:
cisco_2621#sh ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
        D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
        N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
        E1 - OSPF external type 1, E2 - OSPF external type 2
        i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
        ia - IS-IS inter area, * - candidate default, U - per-user static route
        o - ODR, P - periodic downloaded static route

Gateway of last resort is 192.168.10.1 to network 0.0.0.0

R    192.168.30.0/24 [120/1] via 192.168.20.1, 00:00:22, FastEthernet0/1
C    192.168.10.0/24 is directly connected, FastEthernet0/0
C    192.168.20.0/24 is directly connected, FastEthernet0/1
     10.0.0.0/24 is subnetted, 1 subnets
R       10.1.32.0 [120/1] via 192.168.10.1, 00:00:34, FastEthernet0/0
S*    0.0.0.0/0 [1/0] via 192.168.10.1
cisco_2621#_
  
```

Open hyper-terminal /putty software for console access.



Putty Software for Console access of router

- power on the router.
- press **CTRL+ SHIFT + BREAK** to enter in to Rommon mode (with in seconds)



We need to change the config-register file from 0x2012 - 0x2142 in order to skip NVRAM loading in to RAM.

Modular routers

```
Rommon1> confreg 0x2142  
Rommon2> reset
```

Or

On fixed routers

```
> o/r 0x2142  
> i
```

Now the router boots without any passwords (as its skips NVRAM loading in to RAM) and enters in to setup mode .Skip setup mode with NO command.

Router> **enable**

Router #**copy startup-config running-config**

(Very important if u dont want to loose the configs in the NVRAM)

Router # **config terminal**

Change the passwords (overwrite with new passwords)

Router(config)#**line console 0**

Router(config-line)#**password cisco123**

Router(config-line)#**login**

Router(config-line)#**end**

ROUTER(config)# **line vty 0 4**

ROUTER(config-line)# **password ccna123**

ROUTER(config-line)# **login**

ROUTER(config-line)# **exit**

ROUTER(config)# **enable secret ccnp123**

ROUTER(config)# **exit**

- Change the config-register file back to 0x2102
- so that it should not skip NVRAM loading at the next reload

Router (config) # **config-register 0x2102**

Router (config) # **end**

Router #**write**

Router #**reload**

After reloading check for configurations are same and you are able to login with new passwords.

Backup & Restore (IOS/configs)

Reachability (between PC & Router)

R-1#sh ip int brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.1.100	YES	manual	up	up

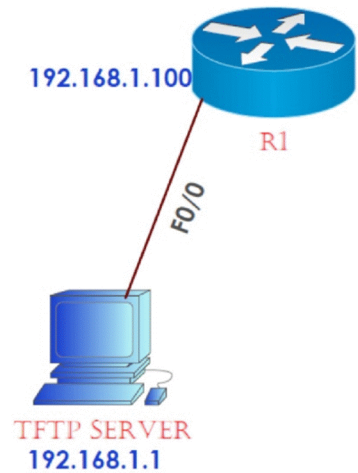
R-1#ping 192.168.1.1

Type escape sequence to abort.

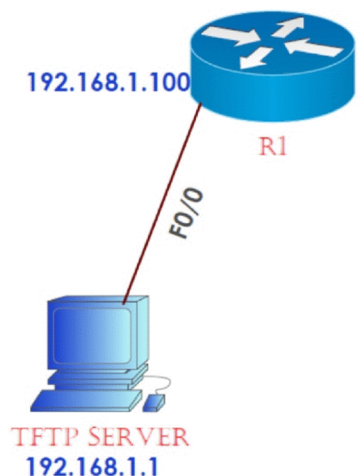
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:

!!!!

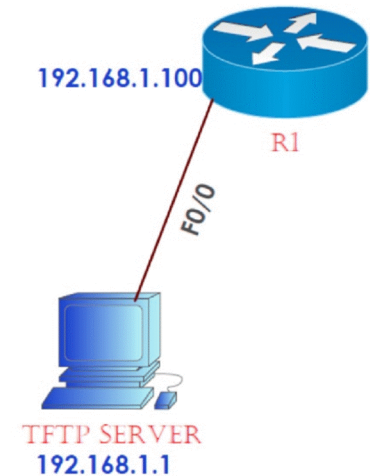
Success rate is 100 percent (5/5), round-trip min/avg/max = 3/7/17 ms



Install any **TFTP application** (example Cisco TFTP, solarwinds TFTP and so on) on PC and make sure that it is running on PC (it is open and minimized)



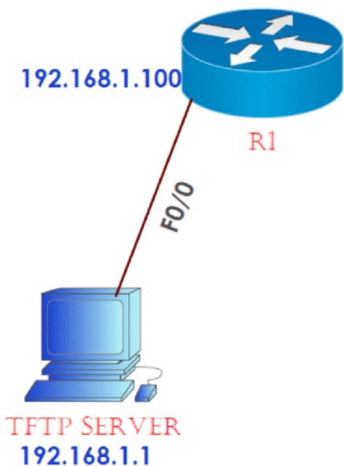
Backup of IOS : # copy flash tftp



R-1#copy flash tftp

```
Source filename []? c2600-i-mz.122-28.bin
Address or name of remote host []? 192.168.1.1
Destination filename [c2600-i-mz.122-28.bin]?
Writing c2600-i-mz.122-
28.bin.....!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
[OK - 5571584 bytes]
5571584 bytes copied in 0.433 secs (12867000 bytes/sec)
```

Restore/upgrade IOS - # copy flash tftp



R-1#copy tftp flash:

```
Address or name of remote host []? 192.168.1.1
Source filename []? c2600-i-mz.122-28.bin
Destination filename [c2600-i-mz.122-28.bin]?

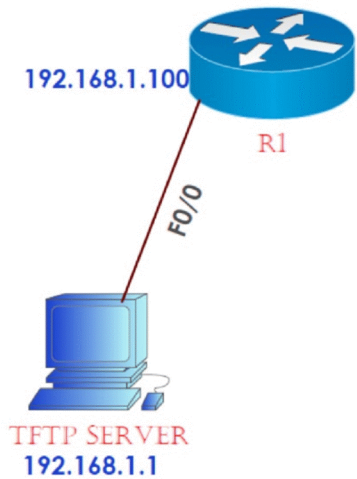
%Warning: There is a file already existing with this name
Do you want to over write? [confirm]
Erase flash: before copying? [confirm]
Erasing the flash filesystem will remove all files! Continue? [confirm]
Erasing device...
eeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeee
eeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeee
Erase of flash: complete
Accessing tftp://192.168.1.1/c2600-i-mz.122-28.bin...
Loading c2600-i-mz.122-28.bin from 192.168.1.1:
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
[OK - 5571584 bytes]

5571584 bytes copied in 0.41 secs (3113699 bytes/sec)
```

Backup configs - # copy startup-config tftp

R-1# copy startup-config tftp:

```
Address or name of remote host []? 192.168.1.1
Destination filename [R-1-config]?
Writing startup-config...!!
[OK - 537 bytes]
537 bytes copied in 0.006 secs (89000 bytes/sec)
```



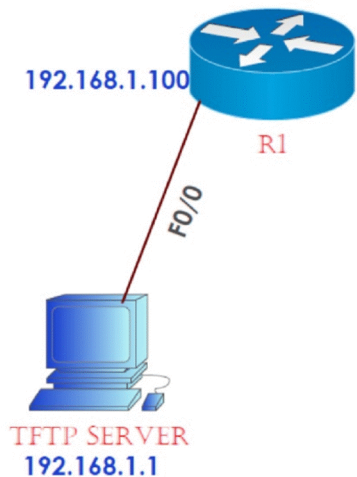
Restore configs - # copy tftp running-config

ROUTER# copy tftp running-config

```
Address or name of remote host []? 192.168.1.1
Source filename []? R-1-config
Destination filename [running-config]?
```

```
Accessing tftp://192.168.1.1/R-1-config...
Loading R-1-config from 192.168.1.1: !
[OK - 537 bytes]
```

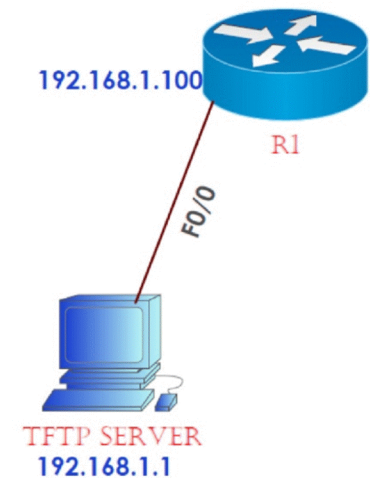
```
537 bytes copied in 0.002 secs (268500 bytes/sec)
```



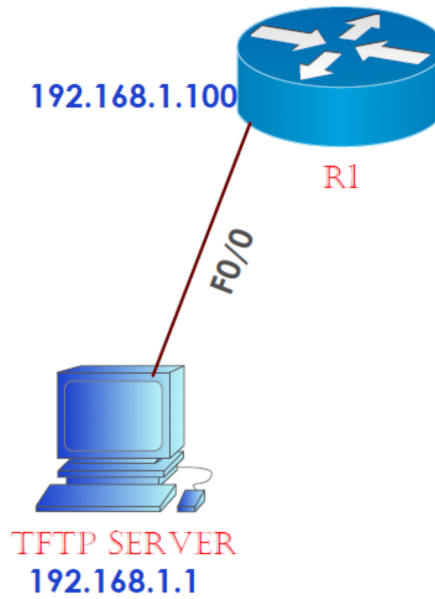
Restoring IOS via TFTP

(In case if there is no IOS present in the flash)

```
rommon 1 > tftpdnld
rommon 2 > IP_ADDRESS=192.168.1.100
rommon 3 > IP_SUBNET_MASK=255.255.255.0
rommon 4 > DEFAULT_GATEWAY=192.168.1.100
rommon 5 > TFTP_SERVER=192.168.1.1
rommon 6 > TFTP_FILE=c2600-i-mz.122-28.bin
rommon 7 > tftpdnld
```



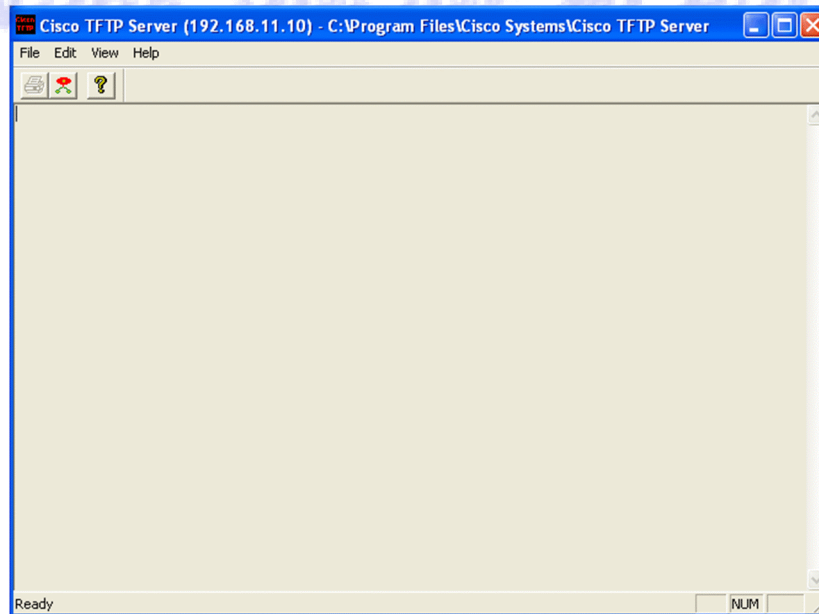
LAB: BACKUP AND RESTORE IOS AND CONFIGS



TASK:

- Configure R1 to take backup of IOS, configurations.
- Verify by restoring the configs again back

Install any TFTP application (example Cisco TFTP, solarwinds TFTP and so on) on PC and make sure that it is running on PC (it is open and minimized)



- ```
R-1#sh ip int brief
```

```
R-1#ping 192.168.1.1
```

```
R-1#sh flash
```

R-1#copy flash tftp

```
Source filename []? c2600-i-mz.122-28.bin
Address or name of remote host []? 192.168.1.1
Destination filename [c2600-i-mz.122-28.bin]?
```

[illegible]

5571584 bytes copied in 0.433 secs (12867000 bytes/sec)

## TASK: Configure the R1 to Take the Backup of configuration in NVRAM

```
Address or name of remote host []? 192.168.1.1
Source filename []? c2600-i-mz.122-28.bin
Destination filename [c2600-i-mz.122-28.bin]?
```

Do you want to over write? [confirm]

Erasing the flash filesystem will remove all files! Continue? **[confirm]**

```

#####
...erased

```

Accessing tftp://192.168.1.1/c2600-i-mz.122-28.bin...

[illegible]

[OK - 5571584 bytes]

5571584 bytes copied in 0.41 secs (3113699 bytes/sec)

## TASK: Configure the R1 to Take the Backup of configuration in NVRAM

Address or name of remote host []? 192.168.1.1

Writing startup-config...!!

[OK - 537 bytes]

537 bytes copied in 0.006 secs (89000 bytes/sec)

### TASK: Configure the R1 to restore the configuration in to RAM

Address or name of remote host []? 192.168.1.1

Source filename []? R-1-config

Destination filename [running-config]?

Accessing tftp://192.168.1.1/R-1-config...

Loading R-1-config from 192.168.1.1: !

[OK - 537 bytes]

537 bytes copied in 0.002 secs (268500 bytes/sec)

R-1#

%SYS-5-CONFIG I: Configured from console by console



## RESTORE IOS IN ROMMON MODE:

Commands Step By Step For Configuring An Ip Address To The Router And Tftp For A Router Which Has No Ios In Flash In Order To Load Ios From Pc

By default router goes in to rommon mode if there is no IOS in the flash (booting from ROM )

- tftpdnld
- IP\_address = 192.168.1.100
- ip\_subnet\_mask=255.255.255.0
- default\_gateway = 192.168.1.100
- tftp\_server = 192.168.1.1
- tftp\_file = <filename>
- tftpdnld

## LAB: RESTORING THE IOS FROM TFTP IN TO IOS (IN CASE IF THERE IS NO IOS PRESENT IN THE FLASH)

### TASK:

- Delete the existing IOS from the flash ( Try this in Packet Tracer)
- If using Real devices ensure that you take the backup of IOS before you do this for testing
- Configure steps to download IOS from TFTP and Load in to the Flash

R-1#sh flash:

System flash directory:

File Length Name/status

4 5571584 c2600-i-mz.122-28.bin

[5571584 bytes used, 58444800 available, 64016384 total]

63488K bytes of processor board System flash (Read/Write)

R-1#delete flash:c2600-i-mz.122-28.bin

Delete filename [c2600-i-mz.122-28.bin]?

Delete flash:/c2600-i-mz.122-28.bin? **[confirm]**

R-1#reload

Proceed with **reload? [confirm]**

%SYS-5-RELOAD: Reload requested by console. Reload Reason: Reload Command.

System Bootstrap, Version 12.1(3r)T2, RELEASE SOFTWARE (fc1)

Copyright (c) 2000 by cisco Systems, Inc.

cisco 2621 (MPC860) processor (revision 0x200) with 60416K/5120K bytes of memory

Boot process failed...

The system is unable to boot automatically. The BOOT environment variable needs to be set to a bootable image.

rommon 1 >

Now the Router enters in to Rommon Mode as there is no IOS present in the Flash

Configure steps to download IOS from TFTP and Load in to the Flash

rommon 1 > tftpdnld

Missing or illegal ip address for variable IP\_ADDRESS  
Illegal IP address.

usage: tftpdnld

Use this command for disaster recovery only to recover an image via TFTP.  
Monitor variables are used to set up parameters for the transfer.  
(Syntax: "VARIABLE\_NAME=value" and use "set" to show current variables.)  
"ctrl-c" or "break" stops the transfer before flash erase begins.

The following variables are REQUIRED to be set for tftpdnld:

IP\_ADDRESS: The IP address for this unit  
IP\_SUBNET\_MASK: The subnet mask for this unit  
DEFAULT\_GATEWAY: The default gateway for this unit  
TFTP\_SERVER: The IP address of the server to fetch from  
TFTP\_FILE: The filename to fetch

The following variables are OPTIONAL:

TFTP\_VERBOSE: Print setting. 0=quiet, 1=progress(default), 2=verbose  
TFTP\_RETRY\_COUNT: Retry count for ARP and TFTP (default=7)  
TFTP\_TIMEOUT: Overall timeout of operation in seconds (default=7200)  
TFTP\_CHECKSUM: Perform checksum test on image, 0=no, 1=yes (default=1)  
FE\_SPEED\_MODE: 0=10/hdx, 1=10/fdx, 2=100/hdx, 3=100/fdx, 4=Auto(deflt)

rommon 2 > IP\_ADDRESS=192.168.1.100  
rommon 3 > IP\_SUBNET\_MASK=255.255.255.0  
rommon 4 > DEFAULT\_GATEWAY=192.168.1.100  
rommon 5 > TFTP\_SERVER=192.168.1.1  
rommon 6 > TFTP\_FILE=c2600-i-mz.122-28.bin  
rommon 7 > tftpdnld

IP\_ADDRESS: 192.168.1.100  
IP\_SUBNET\_MASK: 255.255.255.0  
DEFAULT\_GATEWAY: 192.168.1.100  
TFTP\_SERVER: 192.168.1.1  
TFTP\_FILE: c2600-i-mz.122-28.bin

Invoke this command for disaster recovery only.

WARNING: all existing data in all partitions on flash will be lost!

Do you wish to continue? y/n: [n]: **y**

[illegible]

Copying file c2600-i-mz.122-28.bin to flash.

Erasing flash at 0x60080000

program flash location 0x60540000

program flash location 0x60550000

System Bootstrap, Version 12.1(3r)T2, RELEASE SOFTWARE (fc1)

cisco 2621 (MPC860) processor (revision 0x200) with 60416K/5120K bytes of memory

#####

## Restricted Rights Legend

subject to restrictions as set forth in subparagraph

Rights clause at FAR sec. 52.227-19 and subparagraph

Software clause at DFARS sec. 252.227-7013.

170 West Tasman Drive

San Jose, California 95134-1706

IOS (tm) C2600 Software (C2600-I-M), Version 12.2(28), RELEASE SOFTWARE (fc5)

Technical Support: <http://www.cisco.com/techsupport>

Copyright (c) 1986-2005 by cisco Systems, Inc.

Compiled Wed 27-Apr-04 19:01 by miwang

cisco 2621 (MPC860) processor (revision 0x200) with 60416K/5120K bytes of memory

M860 processor: part number 0, mask 49

X.25 software, Version 3.0.0.

2 FastEthernet/IEEE 802.3 interface(s)

2 Low-speed serial(sync/async) network interface(s)

32K bytes of non-volatile configuration memory.

63488K bytes of ATA CompactFlash (Read/Write)

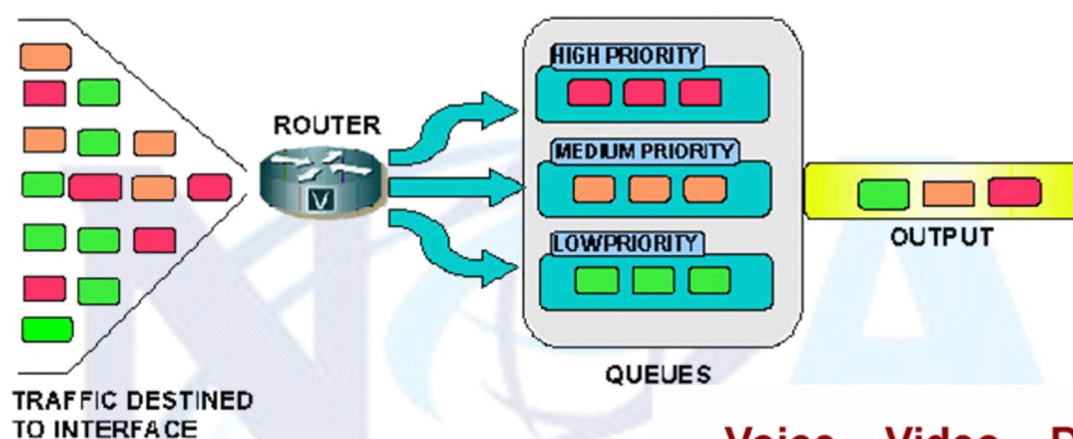
Press RETURN to get started!

ROUTER&gt;



# Quality of Service (Qos)

## Quality of Service



**Voice – Video – Data**



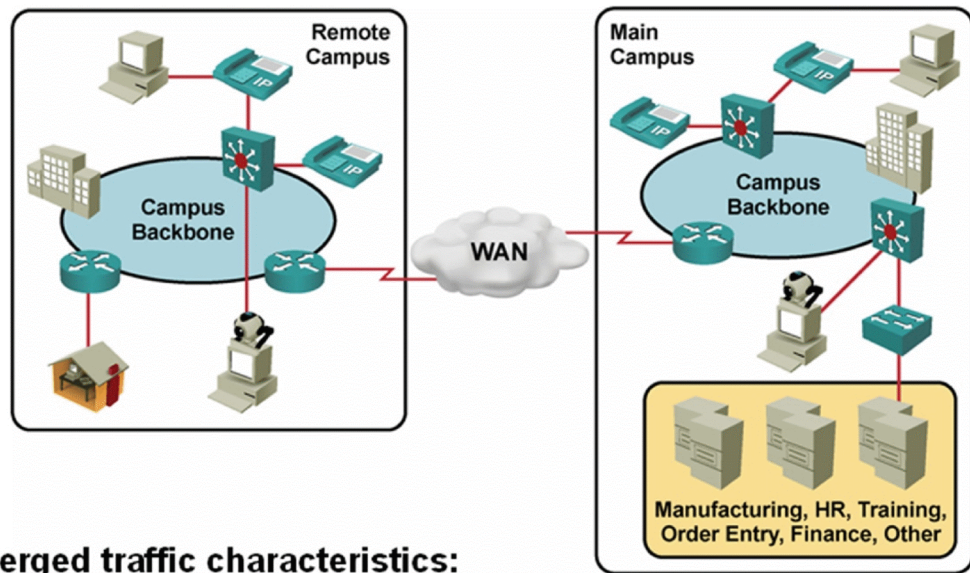
**Consistent and Predictable Performance**

# Introducing QoS



3  
NETWORK ONLINE ACADEMY

# Converged Network Quality Issues

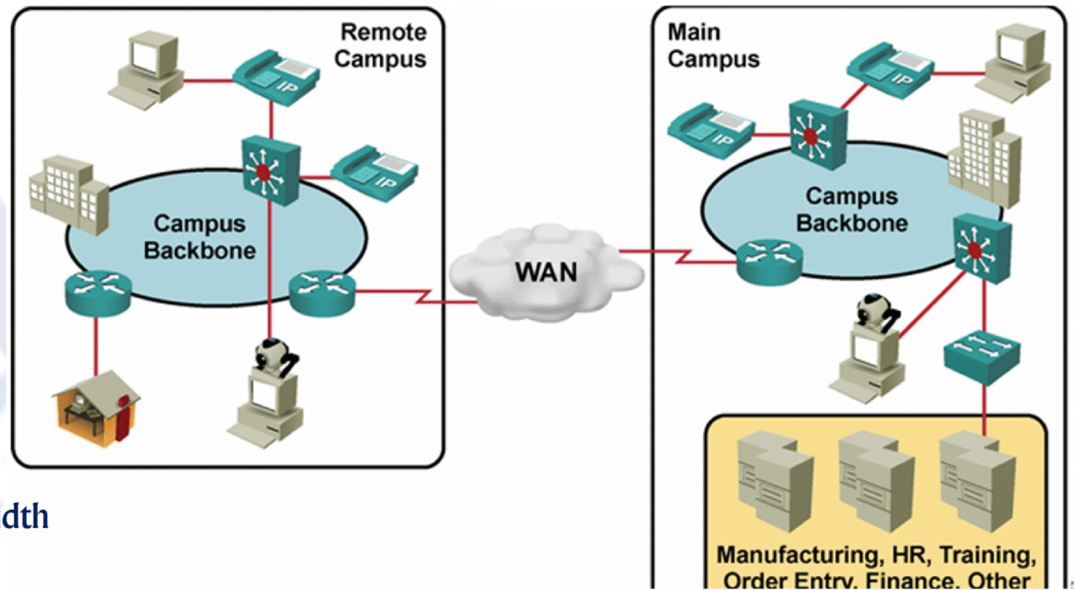


## Converged traffic characteristics:

- Constant small-packet voice flow competes with bursty data flow.
- Critical traffic must get priority.
- Voice and video are time-sensitive.
- Brief outages are not acceptable.

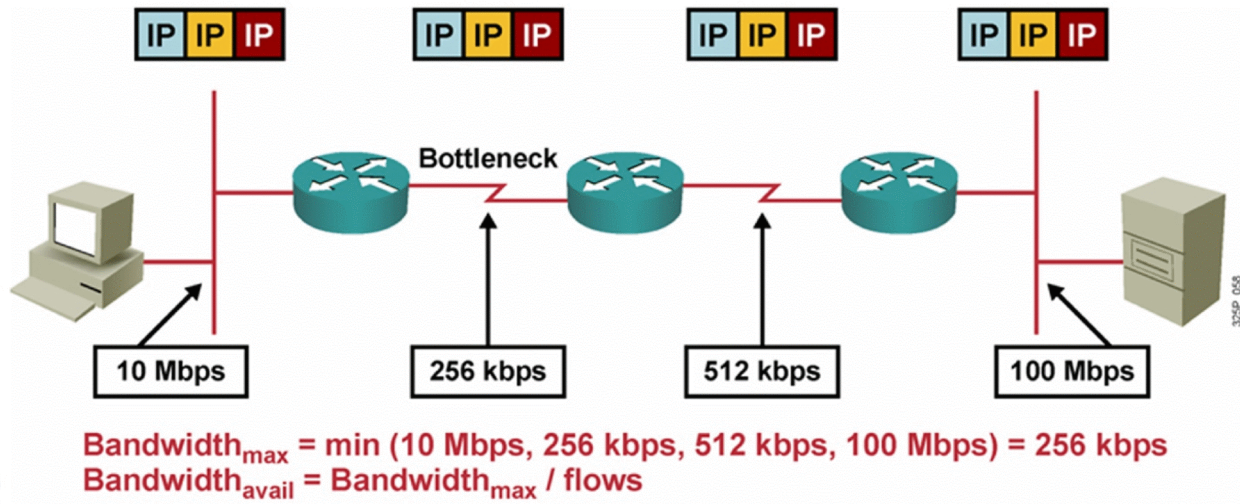


## Converged Network Quality Issues (Cont.)



- Lack of Bandwidth
- Packet loss
- Delay
- Jitter

## Measuring Available Bandwidth



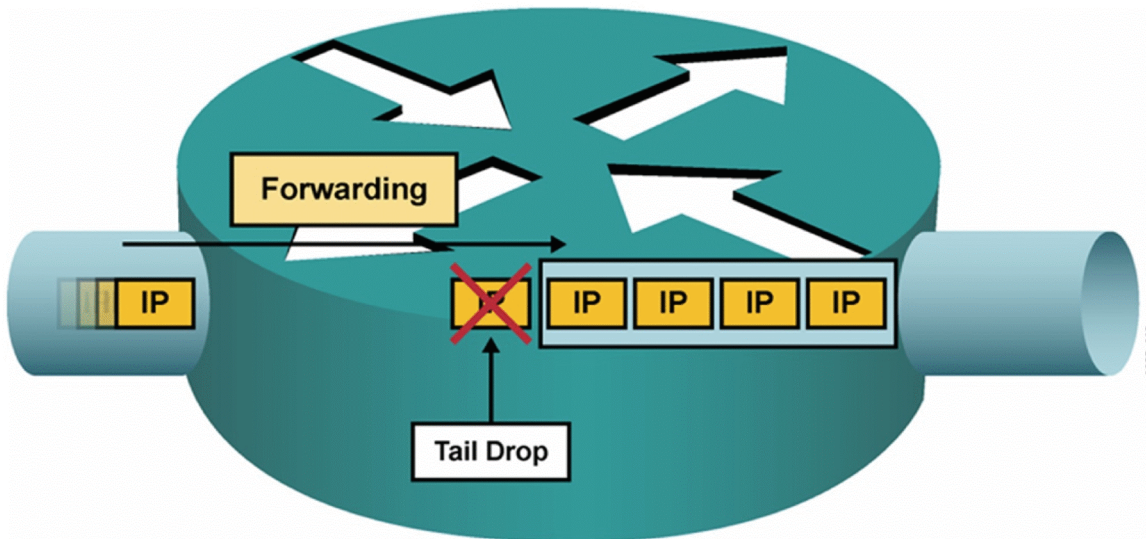
- Maximum available bandwidth equals the bandwidth of the slowest link.
- Multiple flows are competing for the same bandwidth, resulting in much less bandwidth being available to one single application.
- A lack in bandwidth can have performance impacts on network applications.

6

NETWORK ONLINE ACADEMY

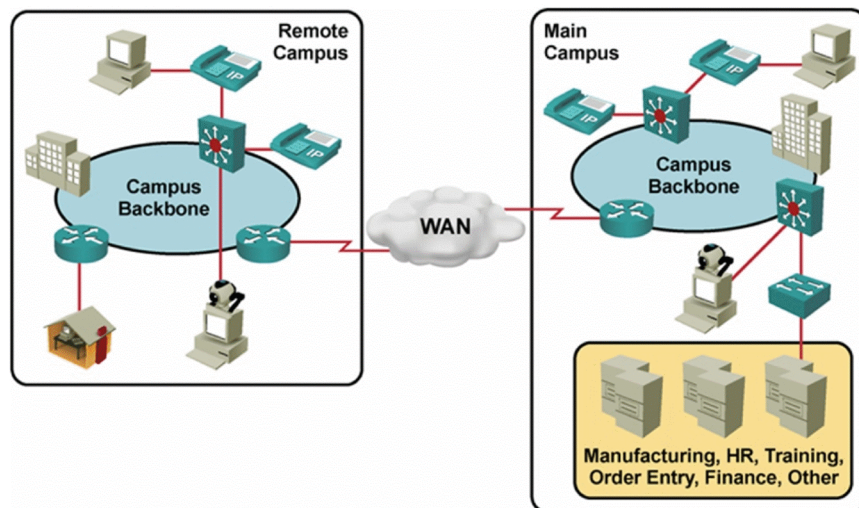


## Impact of Packet Loss (Cont.)



- **Tail drops** occur when the output queue is full. Tail drops are common and happen when a link is congested.

## Impact of Packet Loss

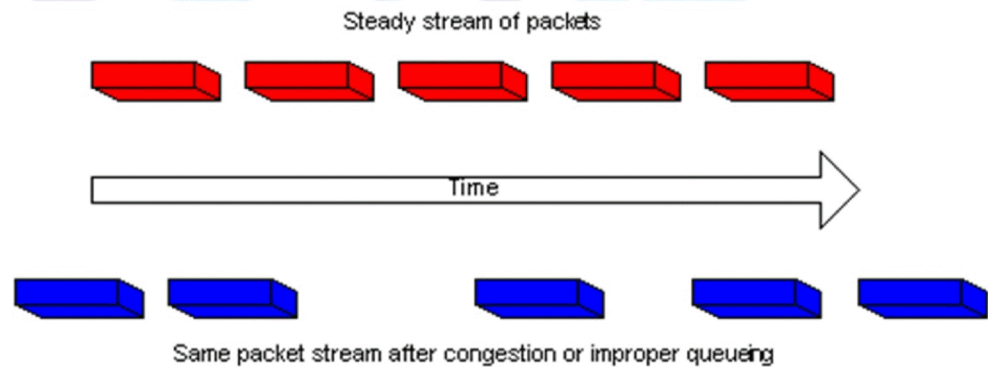


- **Telephone call:** "I cannot understand you. Your voice is breaking up."
- **Teleconferencing:** "The picture is very jerky. Voice is not synchronized."
- **Publishing company:** "This file is corrupted."
- **Call center:** "Please hold while my screen refreshes."

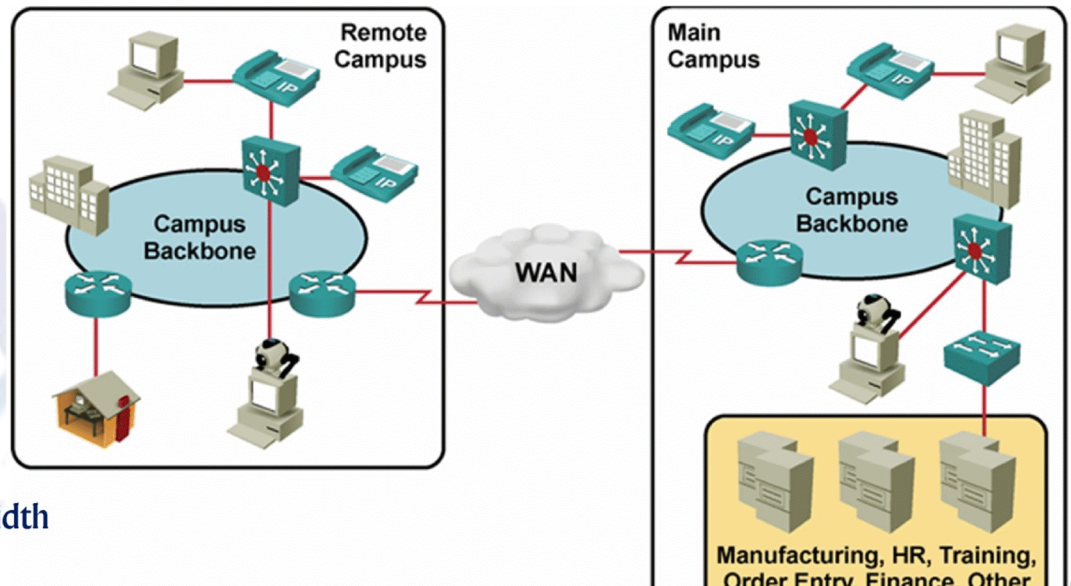


## Jitter

- Packets from the source will reach the destination with different delays.
- Jitter is generally caused by congestion in the IP network.
- The congestion can occur either at the router interfaces or in a provider or carrier network if the circuit has not been provisioned correctly.



## Converged Network Quality Issues (Cont.)



- Lack of Bandwidth
- Packet loss
- Delay
- Jitter

# QoS Mechanisms

## Classification:

- Supported by a class-oriented QoS mechanism

## Marking:

- Used to mark packets based on classification, metering, or both

## Congestion management:

- Used to prioritize the transmission of packets, with a queuing mechanism on each interface

## Congestion avoidance:

- Used to drop packets early to avoid congestion later in the network

## Policing:

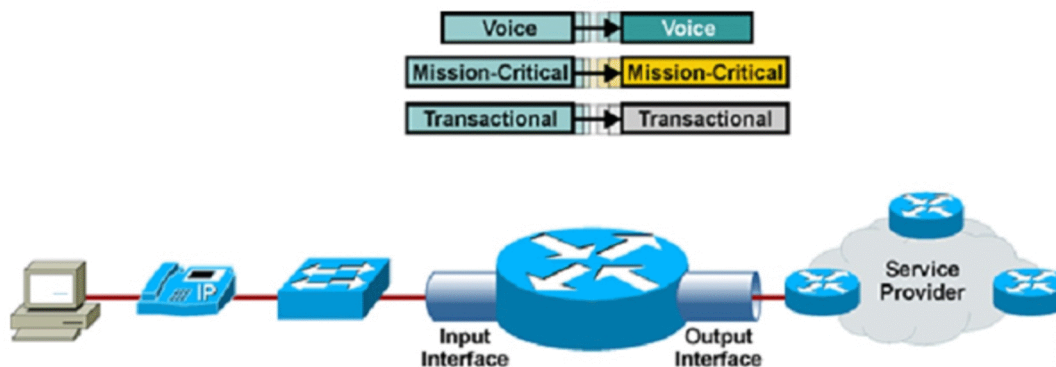
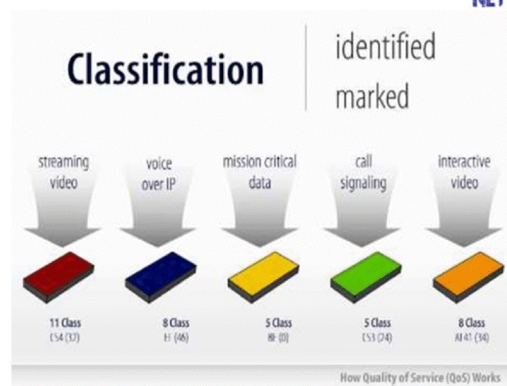
- Used to enforce a rate limit by dropping or marking down packets

## Shaping:

- Used to enforce a rate limit by delaying packets, using buffers

## Classification & marking

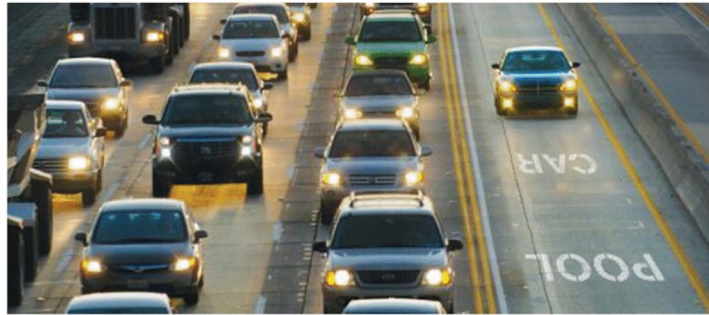
- Supported by a class-oriented QoS mechanism
- Used to mark packets based on classification, metering, or both
- Marking, coloring each packet as a member of a network class so that the packet's class can be quickly recognized throughout the rest of the network





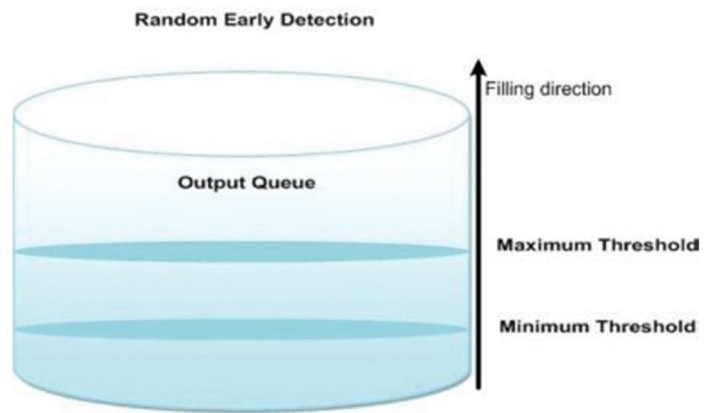
## Congestion management:

- Used to prioritize the transmission of packets, with a queuing mechanism on each interface



## Congestion avoidance:

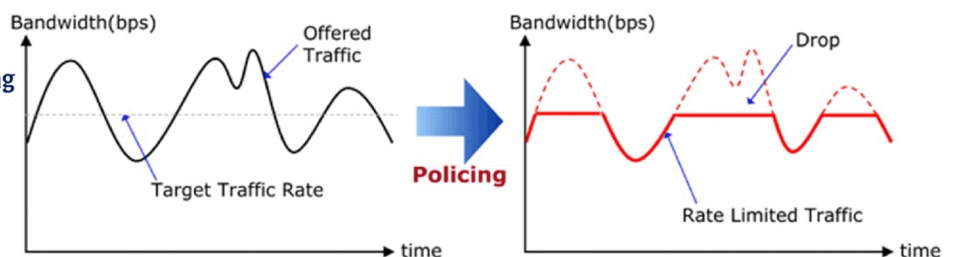
- Used to drop packets early to avoid congestion later in the network



## Policing & Shaping

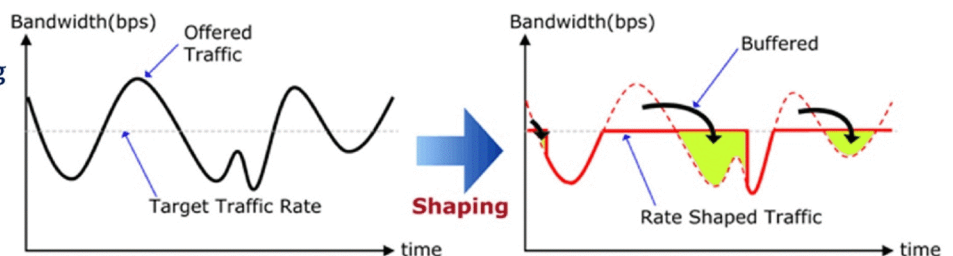
### Policing:

Used to enforce a rate limit by dropping or marking down packets



### Shaping:

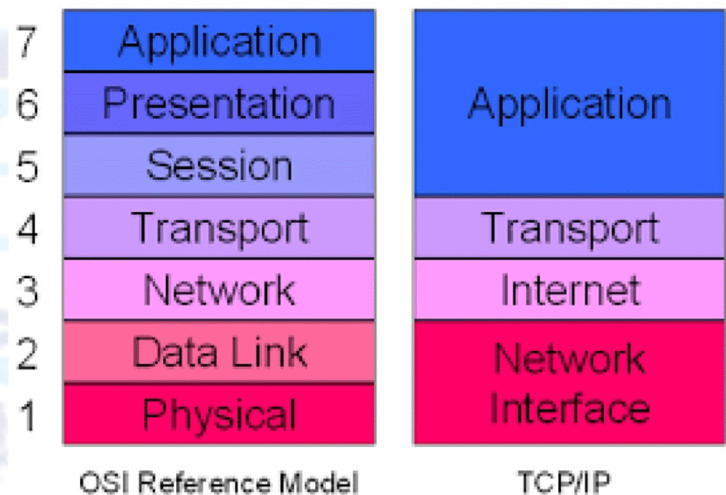
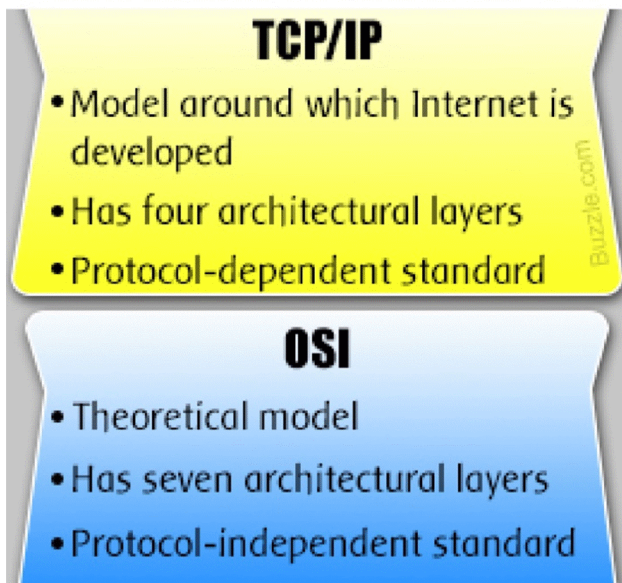
Used to enforce a rate limit by delaying packets, using buffers





# OSI Model & TCP/IP

## OSI Model & TCP/IP



# OSI Model

- ▶ Introduced around 1980.
- ▶ developed by the International Organization for Standardization (ISO)
- ▶ It is a layered architecture (consists of seven layers) which explains how the communication happens in between two or more network devices within the organization or internet.
- ▶ Each layer defines a set of functions in data communication.



## Application Layer (Layer 7)

Provides a user interface for the users to interact with application services or Networking Services.

Ex: Web browser etc.



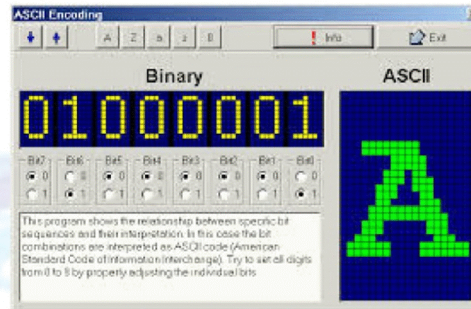


# Presentation Layer (Layer 6)

- ▶ responsible for defining a standard format for the data.
- ▶ It deals with data presentation.

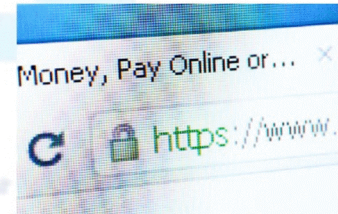
## Encoding – Decoding

- Ex: ASCII, EBCDIC (Text)
- JPEG, GIF, TIFF (Graphics)
- MIDI, WAV (Voice)
- MPEG, DAT, AVI (Video)



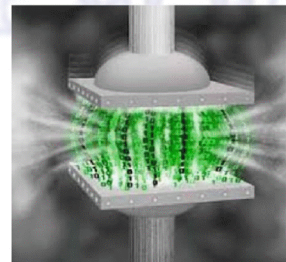
## Encryption – Decryption

- Ex: DES, 3-DES, AES



## Compression – Decompression

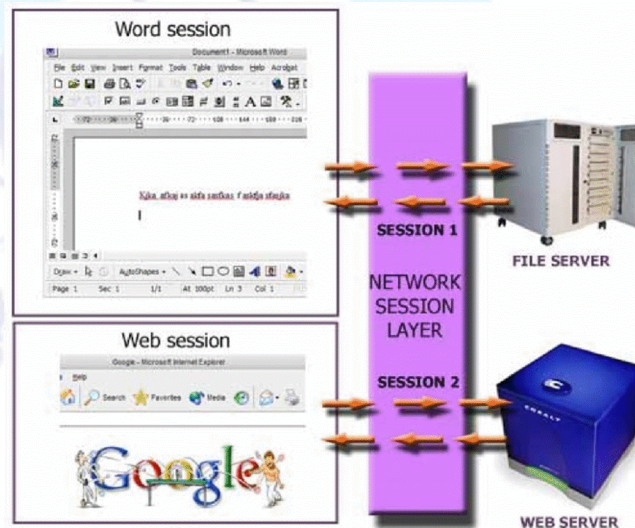
- Ex: Predictor, Stacker, MPPC





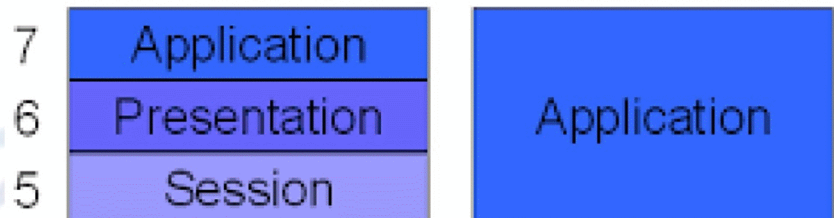
## Session Layer (Layer 5)

- It is responsible for establishing, maintaining and terminating the sessions.
- It deals with sessions or Interactions between the applications.
- Session ID is used to identify a session or interaction
  - Ex: RPC, SQL, NFS



Source: www.teach-ict.com

## Application layer protocols inside TCP/IP

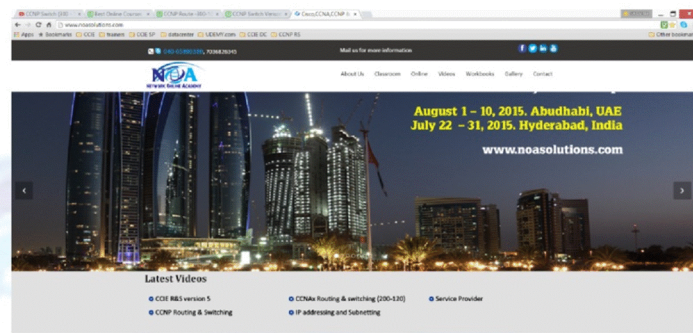


application layer provides an interface between software running on a computer and the network itself Examples for this layer are:

Telnet, FTP, TFTP, SMTP, SNMP, DNS, DHCP etc.

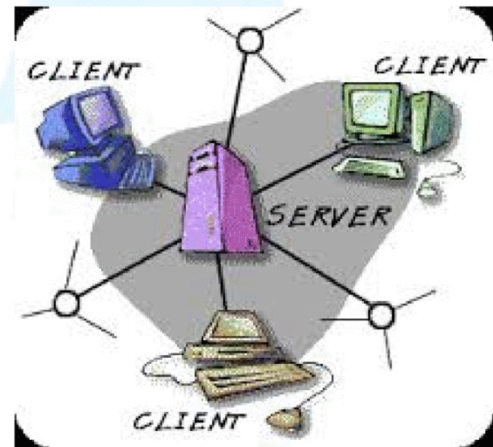
## HTTP

- ▶ Allow to access Webpages.
- ▶ <http://noasolutions.com/>



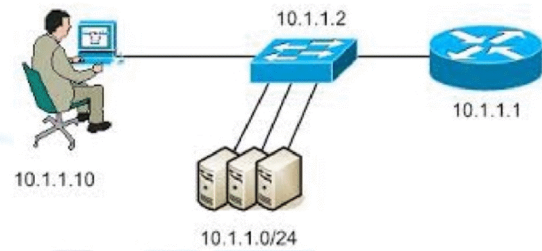
## F T P (File Transfer Protocol)

- ▶ It allows you to transfer files from one machine to another.
- ▶ It also allows access to both directories and files.
- ▶ It uses TCP for data transfer and hence slow but reliable.



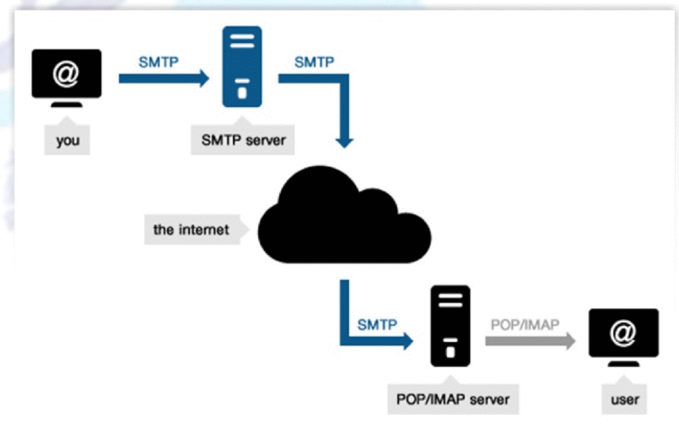
## Telnet

- ▶ Telnet is used for Terminal Emulation.
- ▶ It allows a user sitting on a remote machine to access the resources of another machine.



## SMTP

- ▶ Allow you to send and receive emails messages



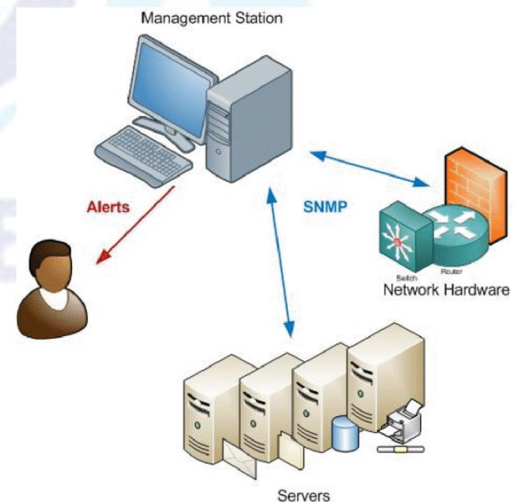


## T F T P (Trivial File Transfer Protocol)

- This is stripped down version of FTP.
- It has no directory browsing abilities.
- It can only send and receive files.
- It uses UDP for data transfer and hence faster but not reliable.

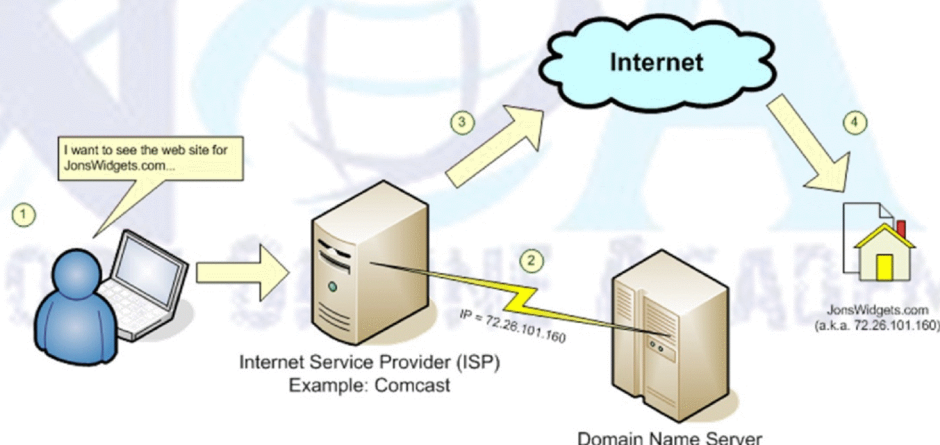
## Simple Network Management Protocol

- SNMP enable a central management of Network.
- Using SNMP an administrator can watch the entire network.
- SNMP works with TCP/IP.
- IT uses UDP for transportation of the data.



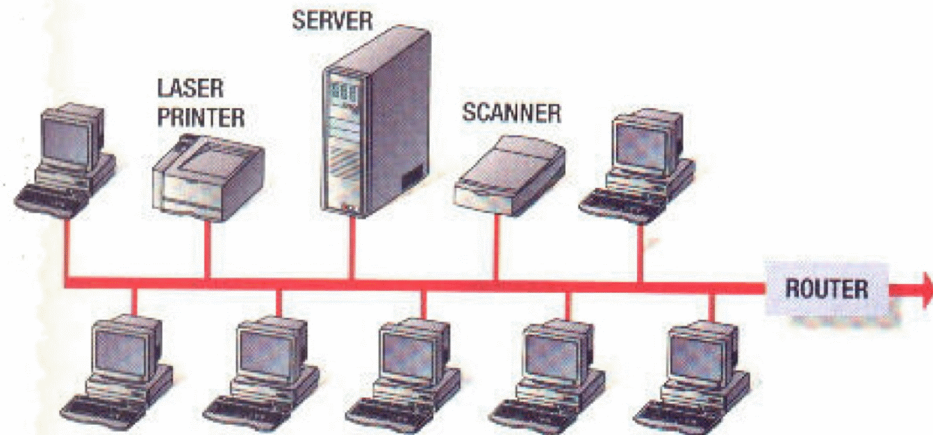
## DNS (Domain Name Service)

- DNS resolves FQDN with IP address.
- DNS allows you to use a domain name to specify and IP address.
- It maintains a database for IP address and Hostnames.



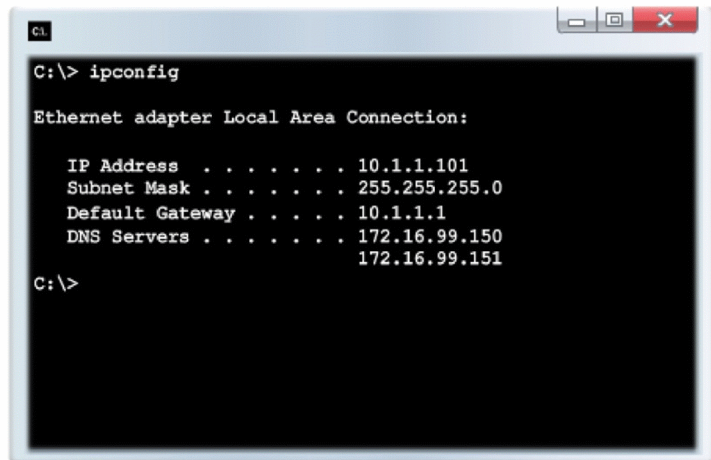
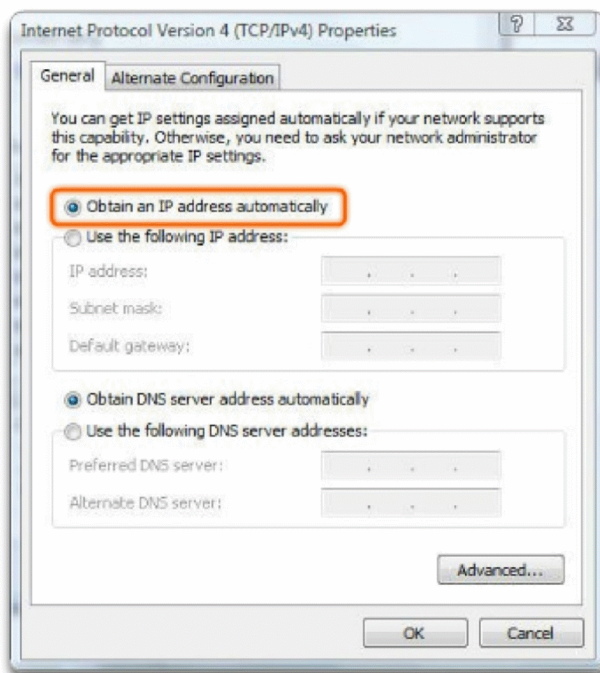
## DHCP (Dynamic Host Configuration Protocol)

- Dynamically assigns IP address to hosts.
- Also provide DNS and Gateway information if needed



## Assigning a Dynamic IPv4 Address to a Host

### Assigning a Dynamic IPv4 Address



**DHCP** - preferred method of “leasing” IPv4 addresses to hosts on large networks, reduces the burden on network support staff and virtually eliminates entry errors



## Transport Layer (Layer 4)

Responsible for end-to-end transportation of data between the applications.

The major functions described at the Transport Layer are...

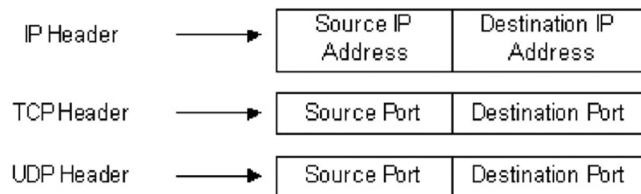
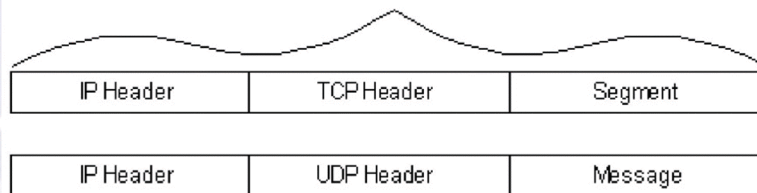
- Identifying Service
- Multiplexing & De-multiplexing
- Segmentation
- Sequencing & Reassembling
- Error Correction
- Flow Control

- ▶ Identification of Services is done using Port Numbers.
- ▶ Port is a logical communication Channel
- ▶ Port number is a 16 bit identifier.

- Total No. Ports 0 – 65535
- Reserved Ports 1 - 1023
- Unreserved Ports 1024 – 65535

| Service | Port No. |
|---------|----------|
| HTTP    | 80       |
| FTP     | 21       |
| SMTP    | 25       |
| TELNET  | 23       |
| TFTP    | 69       |

Sample IP Packet



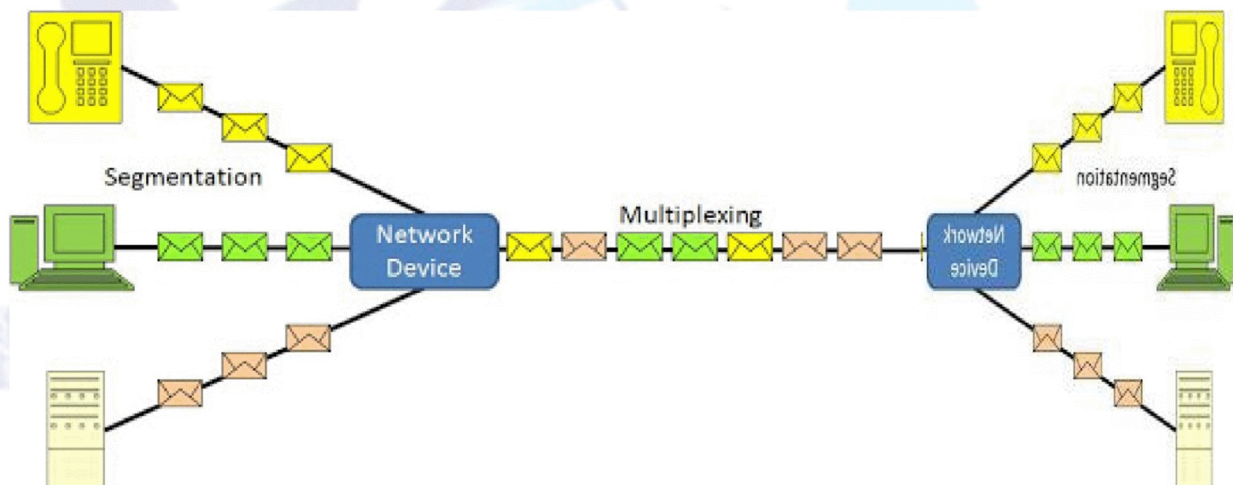


- ▶ Services are identified at this layer with the help of Port No's.
- ▶ The major protocols which takes care of Data Transportation at Transport layer are...TCP, UDP

| TCP                                                                                                                                                                                                                                                               | UDP                                                                                                                                                                                                                                                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• Transmission Control Protocol</li> <li>• Connection Oriented</li> <li>• Reliable communication( with Ack's )</li> <li>• Slower data Transportation</li> <li>• Protocol No is 6</li> <li>• Eg: HTTP, FTP, SMTP</li> </ul> | <ul style="list-style-type: none"> <li>• User Datagram Protocol</li> <li>• Connection Less</li> <li>• Unreliable communication(no Ack's )</li> <li>• Faster data Transportation</li> <li>• Protocol No is 17</li> <li>• Eg: DNS, DHCP, TFTP</li> </ul> |

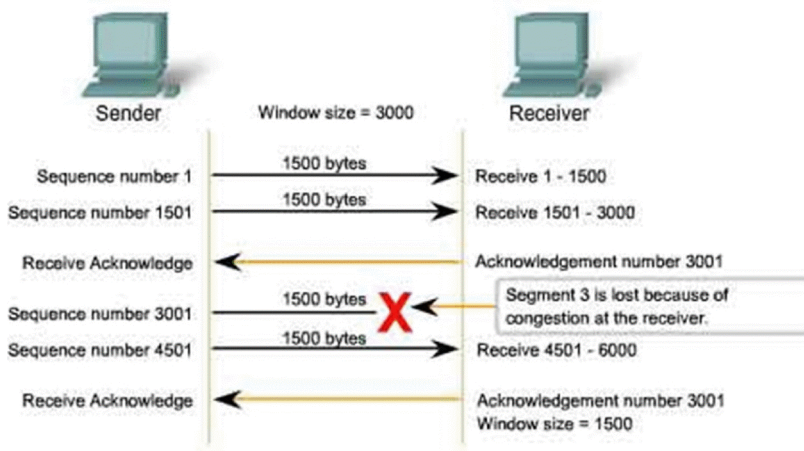
## Segmentation

## Multiplexing & Demultiplexing

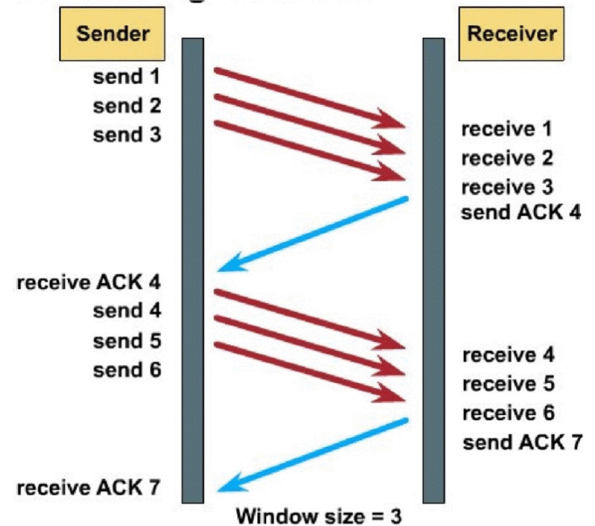


## Flow Control

TCP Congestion and Flow Control

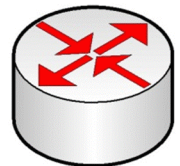


If segments are lost because of congestion, the Receiver will acknowledge the last received sequential segment and reply with a reduced window size.



## Network Layer (Layer 3)

- It is responsible for end-to end Transportation of data across multiple networks.
- Logical addressing & Path determination (Routing) are described at this layer.
- The protocols works at Network layer are

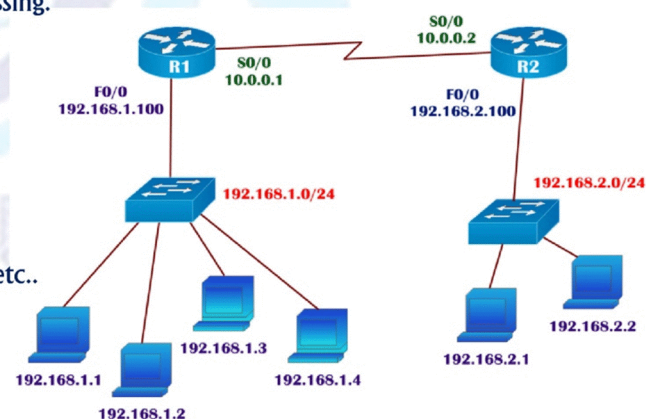


### Routed Protocols:

- Routed protocols acts as data carriers and defines logical addressing.
- IP, IPX, AppleTalk... Etc

### Routing Protocols:

- Routing protocols performs Path determination (Routing).
- RIP, IGRP, EIGRP, OSPF.. Etc
- Devices works at Network Layer are Router, Multilayer switch etc..

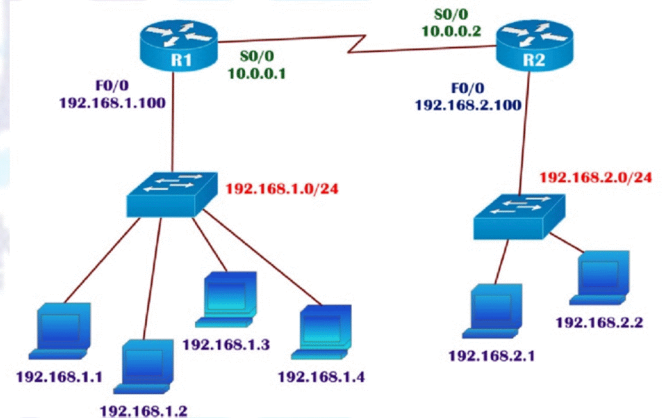




## Data-link Layer (Layer 2)

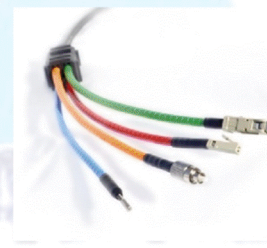
It is responsible for end-to-end delivery of data between the devices on a LAN Network segment. Data link layer comprises of two sub-layers.

- ▶ It deals with hardware addresses (MAC addresses).
- ▶ Devices works at Data link layer are Switches.



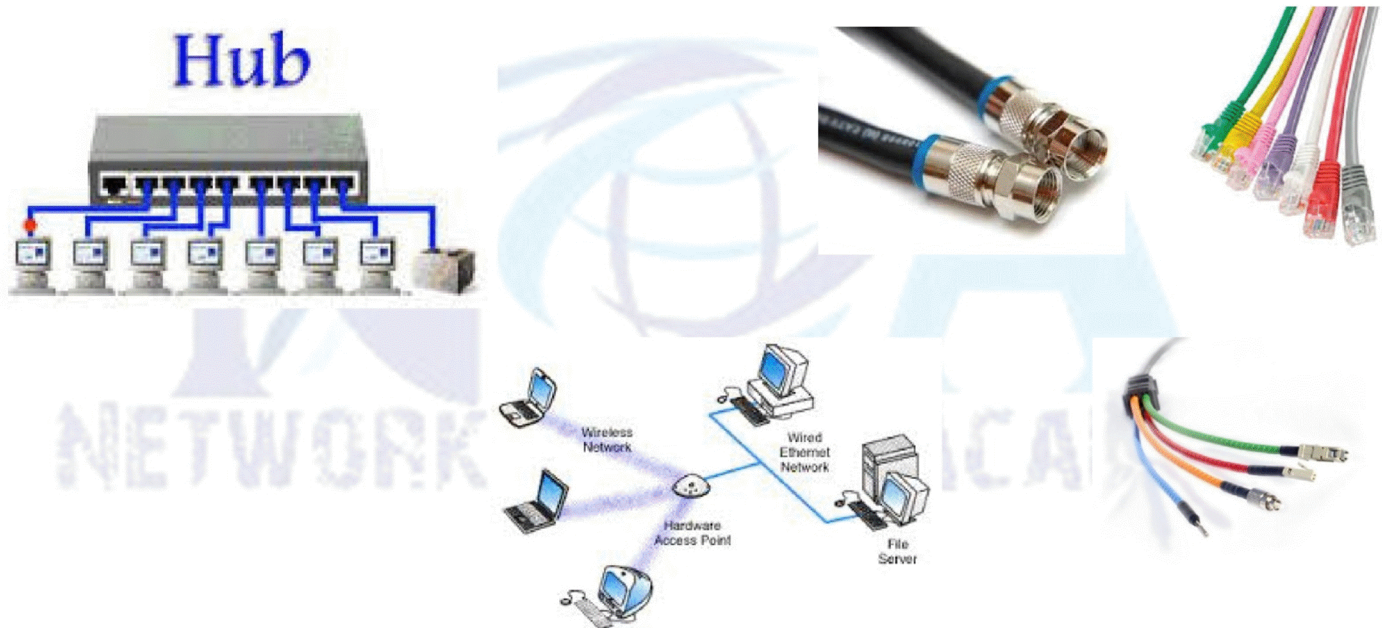
## Physical Layer (Layer 1)

- ▶ It deals with physical transmission of Binary data on the given media (copper, Fiber, wireless...).
- |                    |                                          |
|--------------------|------------------------------------------|
| ◦ Copper media :   | Electrical signals of different voltages |
| ◦ Fiber media :    | Light pulses of different wavelengths    |
| ◦ Wireless media : | Radio frequency waves                    |

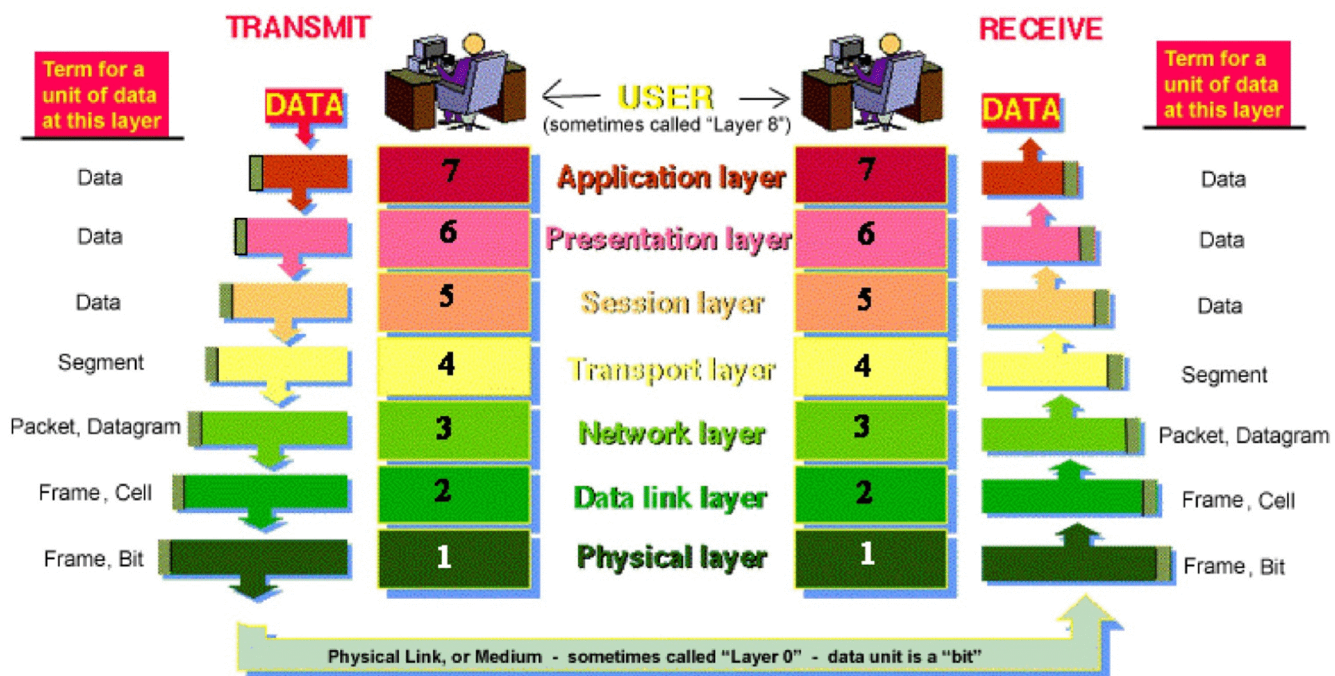


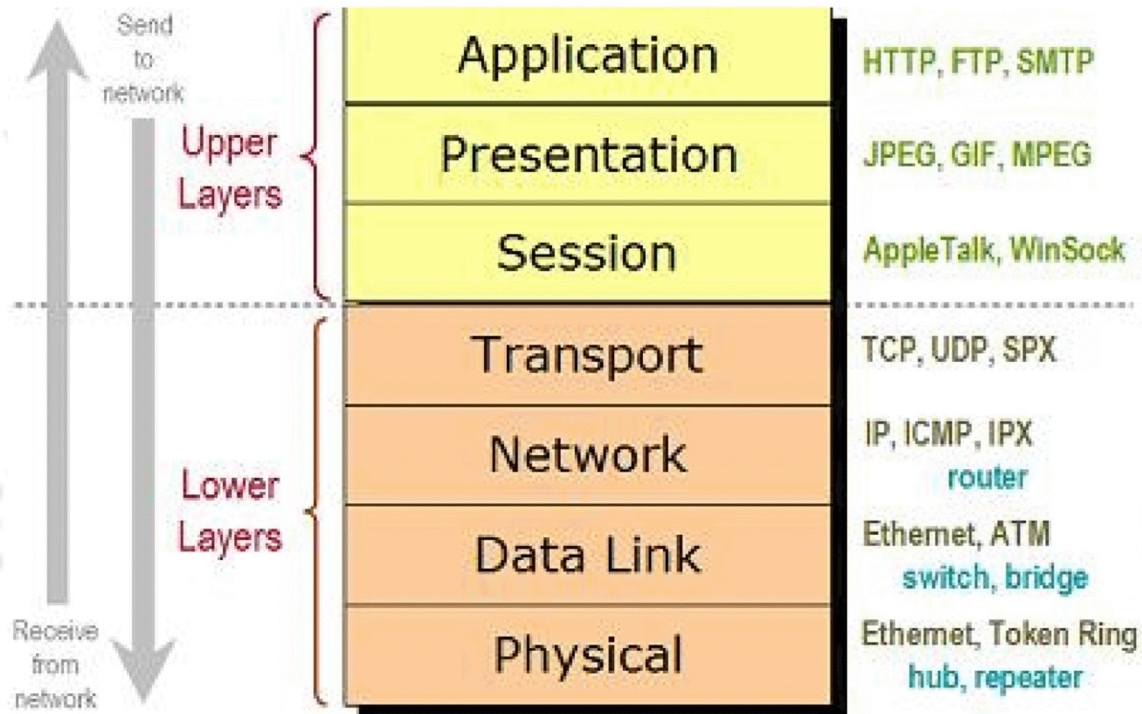


Devices works at physical layer are  
Hub, Modems, Repeater, and Transmission Media



## OSI Model Format





NETWORK ONLINE ACADEMY



# Troubleshooting

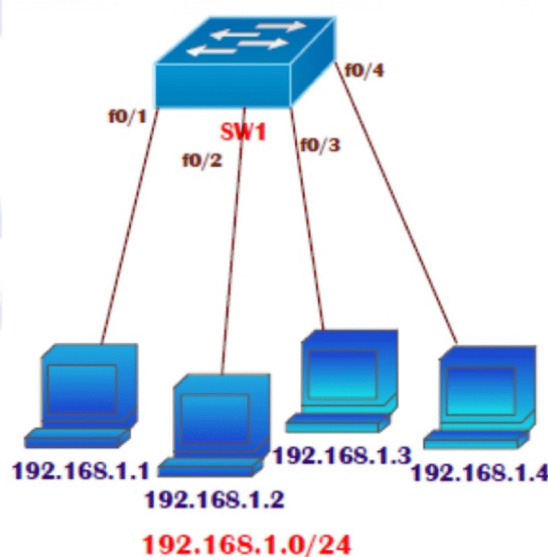
## Routing & Switching

### Troubleshooting User Connectivity



#### Physical connectivity:

- Make sure the cable, network adapter, and switch port are good.
- Check the port's link LED.





## Switch Port/Interface Issues

### No cable connected:

- Connect the cable from the switch to a known good device.

### Wrong port:

- Make sure that both ends of the cable are plugged into the correct ports.

### Device has no power

- Ensure that both devices have power.

### Wrong cable type

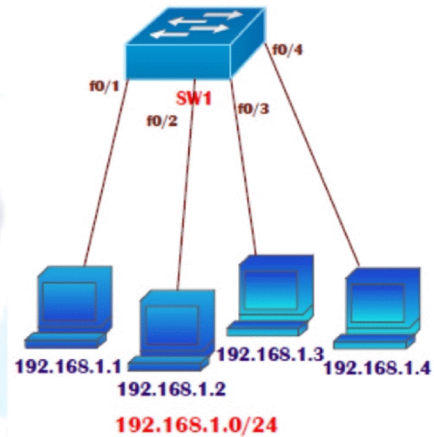
- Verify that the correct type of cable is being used.

### Bad cable:

- Swap the suspect cable with a known good cable. Look for broken or missing pins on connectors.

### Loose connections:

- Check for loose connections. Sometimes a cable appears to be seated in the jack, but it is not. Unplug the cable and reinsert it.



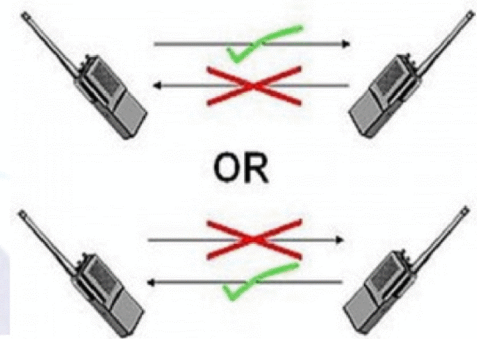
### SW1#sh interfaces status

| Port          | Name | Status            | Vlan       | Duplex      | Speed       | Type                |
|---------------|------|-------------------|------------|-------------|-------------|---------------------|
| <b>Fa1/0</b>  |      | <b>notconnect</b> | <b>1</b>   | <b>auto</b> | <b>auto</b> | <b>10/100BaseTX</b> |
| Fa1/1         |      | connected         | trunk      | full        | 100         | 10/100BaseTX        |
| Fa1/2         |      | connected         | trunk      | full        | 100         | 10/100BaseTX        |
| Fa1/3         |      | connected         | trunk      | full        | 100         | 10/100BaseTX        |
| Fa1/4         |      | connected         | trunk      | full        | 100         | 10/100BaseTX        |
| Fa1/5         |      | connected         | 15         | full        | 100         | 10/100BaseTX        |
| Fa1/6         |      | connected         | 16         | full        | 100         | 10/100BaseTX        |
| Fa1/7         |      | connected         | 11         | full        | 100         | 10/100BaseTX        |
| Fa1/8         |      | connected         | 18         | full        | 100         | 10/100BaseTX        |
| <b>Fa1/9</b>  |      | <b>notconnect</b> | <b>19</b>  | <b>auto</b> | <b>auto</b> | <b>10/100BaseTX</b> |
| Fa1/10        |      | connected         | 19         | full        | 100         | 10/100BaseTX        |
| Fa1/11        |      | connected         | trunk      | full        | 100         | 10/100BaseTX        |
| Fa1/12        |      | connected         | trunk      | full        | 100         | 10/100BaseTX        |
| Fa1/13        |      | connected         | trunk      | full        | 100         | 10/100BaseTX        |
| <b>Fa1/14</b> |      | <b>disabled</b>   | <b>143</b> | <b>auto</b> | <b>auto</b> | <b>10/100BaseTX</b> |
| Fa1/15        |      | connected         | 21         | full        | 100         | 10/100BaseTX        |

# What is Duplex

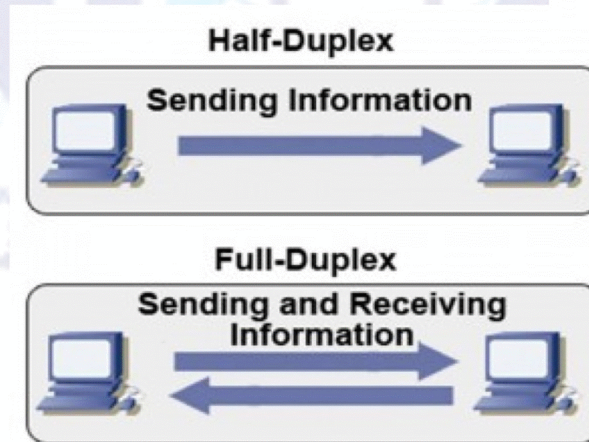
## Half Duplex

- ▶ Hub always works in half duplex mode.

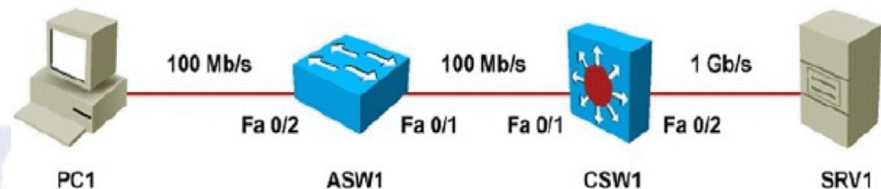


## Full Duplex

- ▶ Switches



## Troubleshooting Example: Duplex/Speed Mismatch



- ▶ The user on PC1 has complained that transferring large files to SRV1 takes hours.
- ▶ The maximum throughput the user can expect is 100 Mbps between the client and the server.
- ▶ Transfer of 1 GB of data at the rate of 100 Mbps should take approximately 80 seconds (not factoring overhead).

### Potential explanations:

- ▶ Congestion on the network or underperforming hardware or software on the client, network, or server.
- ▶ Average load on the links in the path has not been higher than 50 percent over the last few hours, ruling out congestion as the cause.



```
ASW1# show interface FastEthernet 0/1 | include duplex
Full-duplex, 100Mb/s, media type is 10/100Base TX
```

```
ASW1# show interfaces FastEthernet 0/1 counters errors
```

| Port  | Align-Err | FCS-Err | Xmit-Err | Rcv-Err | UnderSize | OutDiscards |
|-------|-----------|---------|----------|---------|-----------|-------------|
| Fa0/1 | 0         | 12618   | 0        | 12662   | 0         | 0           |

| Port  | Single-Col | Multi-Col | Late-Col | Excess-Col | Carri-Sen | Runts | Giants |
|-------|------------|-----------|----------|------------|-----------|-------|--------|
| Fa0/1 | 0          | 0         | 0        | 0          | 0         | 0     | 44     |

```
CSW1# show interface FastEthernet 0/1 | include duplex
Half-duplex, 10Mb/s, media type is 10/100Base TX
```

```
CSW1# show interfaces FastEthernet 0/1 counters errors
```

| Port  | Align-Err | FCS-Err | Xmit-Err | Rcv-Err | UnderSize | OutDiscards |
|-------|-----------|---------|----------|---------|-----------|-------------|
| Fa0/1 | 0         | 0       | 0        | 0       | 0         | 0           |

| Port  | Single-Col | Multi-Col | Late-Col | Excess-Col | Carri-Sen | Runts | Giants |
|-------|------------|-----------|----------|------------|-----------|-------|--------|
| Fa0/1 | 664        | 124       | 12697    | 0          | 0         | 0     | 44     |

- ▶ A mismatched manual speed and duplex configuration has caused this.
- ▶ Configure both sides for **auto-negotiation**, **clear the counters**, and confirm that the negotiation results in full duplex.
- ▶ Verify on the switches that the **FCS** and **collision counters** do not increase.

Switch(config)#int f0/1

Switch(config-if)#speed ?

- 10 Force 10 Mbps operation
- 100 Force 100 Mbps operation
- auto Enable AUTO speed configuration

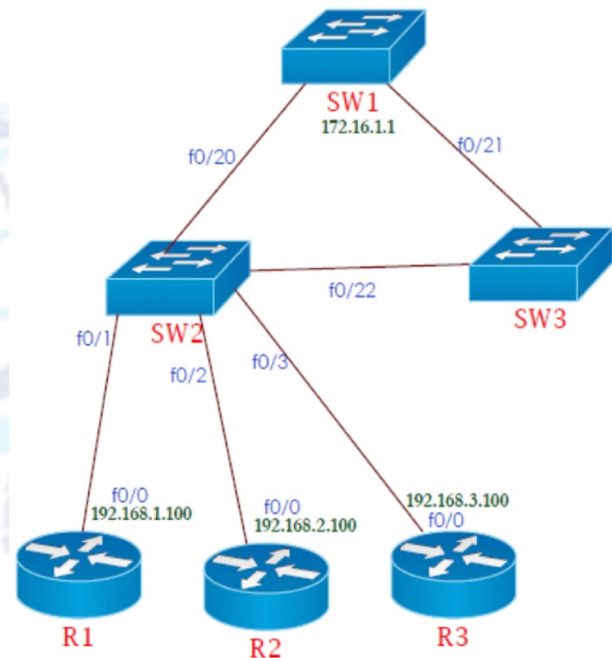
Switch(config-if)#duplex ?

- auto Enable AUTO duplex configuration
- full Force full duplex operation
- half Force half-duplex operation



# Cisco Discovery protocol

- ▶ proprietary protocol developed by Cisco Systems.
- ▶ It is used to share information about other directly connected Cisco equipment, such as the connected ports ,operating system version and IP address.
- ▶ By default, CDP announcements are sent every 60 seconds on interfaces
- ▶ From a troubleshooting perspective, CDP can be used to either confirm or fix the documentation shown in a network diagram, or even discover the devices and interfaces used in a network.
- ▶ The show cdp neighbor command delivers information about directly connected devices.



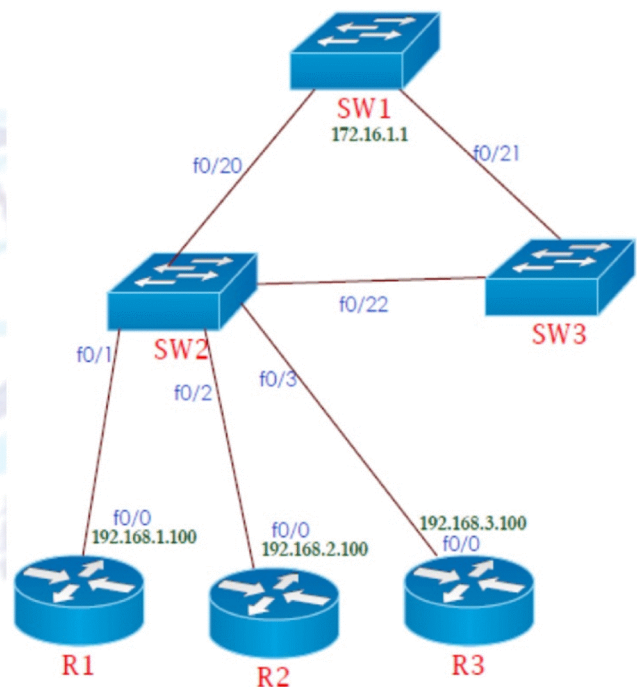
The show cdp neighbor command delivers information about directly connected devices.

## #sh cdp neighbors

Device ID  
Local Interface  
Holdtime  
Capability  
Platform  
Port ID

## # sh cdp neighbors detail

## # sh cdp interface

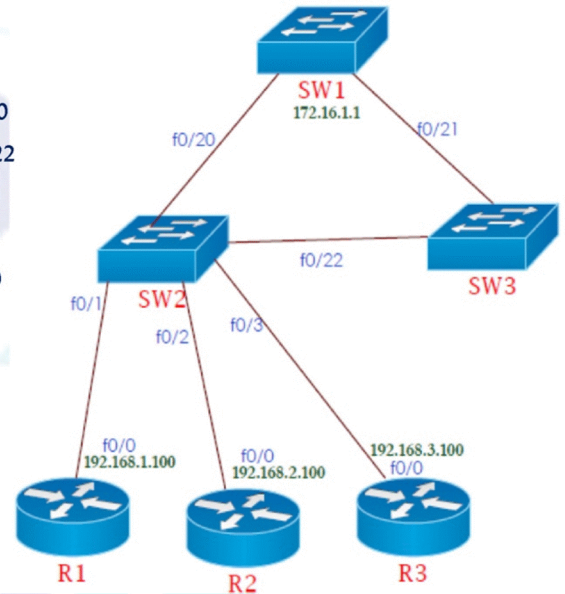


## SW-2#sh cdp neighbors

Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge

S - Switch, H - Host, I - IGMP, r - Repeater, P - Phone

| Device ID | Local Intrfce | Holdtme | Capability | Platform | Port ID  |
|-----------|---------------|---------|------------|----------|----------|
| R-1       | Fas 0/1       | 134     | R          | C2600    | Fas 0/0  |
| Switch    | Fas 0/22      | 115     | S          | 2950     | Fas 0/22 |
| R-2       | Fas 0/2       | 138     | R          | C1841    | Fas 0/0  |
| R-3       | Fas 0/3       | 160     | R          | C2800    | Fas 0/0  |
| SW-1      | Fas 0/20      | 168     |            | 3560     | Fas 0/20 |
| SW3       | Fas 0/22      | 175     | S          | 2950     | Fas 0/22 |



SW-2#sh cdp neighbors detail

Device ID: R-1

Entry address(es):

IP address : 192.168.1.100

Platform: cisco C2600, Capabilities: Router

Interface: FastEthernet0/1, Port ID (outgoing port): FastEthernet0/0

Holdtime: 125

Version :

Cisco Internetwork Operating System Software

IOS (tm) C2600 Software (C2600-I-M), Version 12.2(28), RELEASE SOFTWARE (fc5)

Technical Support: <http://www.cisco.com/techsupport>

Copyright (c) 1986-2005 by cisco Systems, Inc.

Compiled Wed 27-Apr-04 19:01 by miwang

advertisement version: 2

Duplex: full

Device ID: Switch

Entry address(es):

Platform: cisco 2950, Capabilities: Switch

Interface: FastEthernet0/22, Port ID (outgoing port): FastEthernet0/22

Holdtime: 46

Version :

Cisco Internetwork Operating System Software

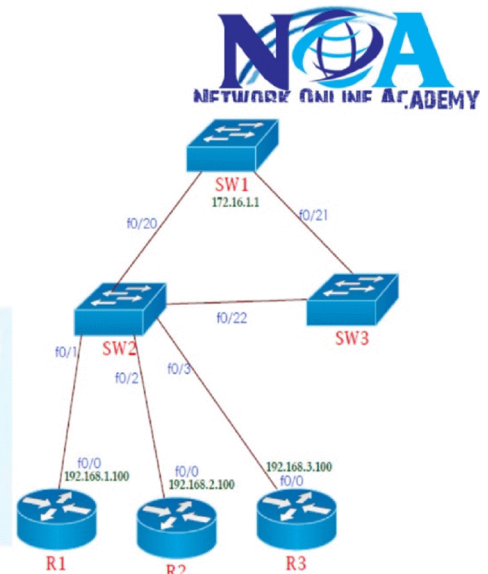
IOS (tm) C2950 Software (C2950-I6Q4L2-M), Version 12.1(22)EA4, RELEASE SOFTWARE(fc1)

Copyright (c) 1986-2005 by cisco Systems, Inc.

Compiled Wed 18-May-05 22:31 by jharirba

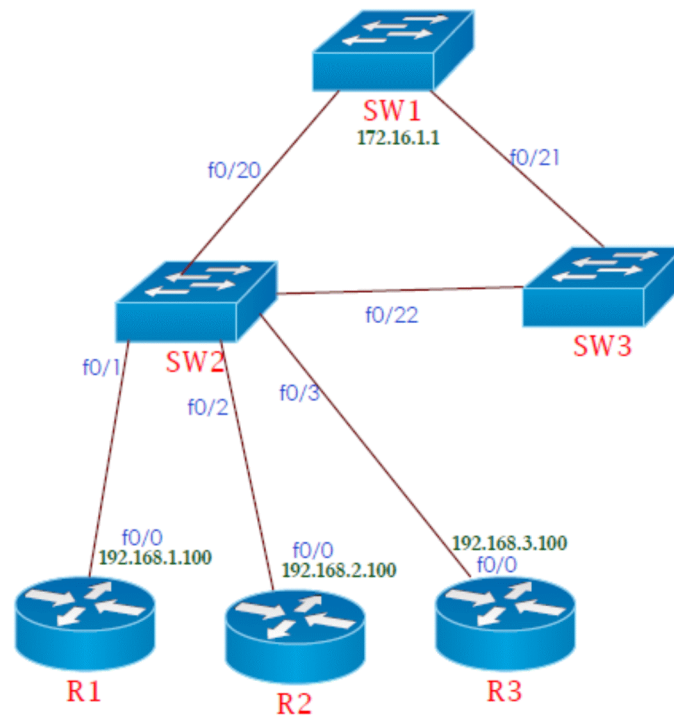
advertisement version: 2

Duplex: full





## LAB: VERIFY CDP



### TASK:

Configure on R1, R2, R3, SW1 using IP address as per the Diagram.

```
R-1(config) #int f0/0
R-1(config-if)#ip address 192.168.1.100 255.255.255.0
R-1(config-if)#no sh
R-1(config-if)#exit
```

```
R-2(config)#int f0/0
R-2(config-if)#ip address 192.168.2.100 255.255.255.0
R-2(config-if)#no sh
R-2(config-if)#exit
```

```
R-3(config)#int f0/0
R-3(config-if)#ip address 192.168.3.100 255.255.255.0
R-3(config-if)#no shutdown
R-3(config-if)#exit
```

```
SW-1(config)#int vlan 1
SW-1(config-if)#ip address 172.16.1.1 255.255.255.0
SW-1(config-if)#no sh
SW-1(config-if)#exit
```

### SW-2#sh cdp neighbors

Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge

S - Switch, H - Host, I - IGMP, r - Repeater, P - Phone

| Device ID | Local Intrfce | Holdtme | Capability | Platform | Port ID  |
|-----------|---------------|---------|------------|----------|----------|
| R-1       | Fas 0/1       | 134     | R          | C2600    | Fas 0/0  |
| Switch    | Fas 0/22      | 115     | S          | 2950     | Fas 0/22 |
| R-2       | Fas 0/2       | 138     | R          | C1841    | Fas 0/0  |
| R-3       | Fas 0/3       | 160     | R          | C2800    | Fas 0/0  |
| SW-1      | Fas 0/20      | 168     |            | 3560     | Fas 0/20 |
| SW3       | Fas 0/22      | 175     | S          | 2950     | Fas 0/22 |

### SW-2#sh cdp

Global CDP information:

Sending CDP packets every 60 seconds

Sending a holdtime value of 180 seconds

Sending CDPv2 advertisements is enabled

### SW-2#sh cdp interface

FastEthernet0/1 is up, line protocol is up

Sending CDP packets every 60 seconds

Holdtime is 180 seconds

FastEthernet0/2 is up, line protocol is up

Sending CDP packets every 60 seconds

Holdtime is 180 seconds

FastEthernet0/3 is up, line protocol is up

Sending CDP packets every 60 seconds

Holdtime is 180 seconds

FastEthernet0/4 is down, line protocol is down

Sending CDP packets every 60 seconds

Holdtime is 180 seconds

FastEthernet0/5 is down, line protocol is down

Sending CDP packets every 60 seconds

Holdtime is 180 seconds

FastEthernet0/6 is down, line protocol is down

Sending CDP packets every 60 seconds

Holdtime is 180 seconds

FastEthernet0/7 is down, line protocol is down

Sending CDP packets every 60 seconds

Holdtime is 180 seconds

FastEthernet0/8 is down, line protocol is down

Sending CDP packets every 60 seconds

Holdtime is 180 seconds

FastEthernet0/9 is down, line protocol is down

Sending CDP packets every 60 seconds

Holdtime is 180 seconds  
FastEthernet0/10 is down, line protocol is down  
Sending CDP packets every 60 seconds  
Holdtime is 180 seconds  
FastEthernet0/11 is down, line protocol is down  
Sending CDP packets every 60 seconds  
Holdtime is 180 seconds  
FastEthernet0/12 is down, line protocol is down  
Sending CDP packets every 60 seconds  
Holdtime is 180 seconds  
FastEthernet0/13 is down, line protocol is down  
Sending CDP packets every 60 seconds  
Holdtime is 180 seconds  
FastEthernet0/14 is down, line protocol is down  
Sending CDP packets every 60 seconds  
Holdtime is 180 seconds  
FastEthernet0/15 is down, line protocol is down  
Sending CDP packets every 60 seconds  
Holdtime is 180 seconds  
FastEthernet0/16 is down, line protocol is down  
Sending CDP packets every 60 seconds  
Holdtime is 180 seconds  
FastEthernet0/17 is down, line protocol is down  
Sending CDP packets every 60 seconds  
Holdtime is 180 seconds  
FastEthernet0/18 is down, line protocol is down  
Sending CDP packets every 60 seconds  
Holdtime is 180 seconds  
FastEthernet0/19 is down, line protocol is down  
Sending CDP packets every 60 seconds  
Holdtime is 180 seconds  
FastEthernet0/20 is up, line protocol is up  
Sending CDP packets every 60 seconds  
Holdtime is 180 seconds  
FastEthernet0/21 is down, line protocol is down  
Sending CDP packets every 60 seconds  
Holdtime is 180 seconds  
FastEthernet0/22 is up, line protocol is up  
Sending CDP packets every 60 seconds  
Holdtime is 180 seconds  
FastEthernet0/23 is down, line protocol is down  
Sending CDP packets every 60 seconds  
Holdtime is 180 seconds  
FastEthernet0/24 is down, line protocol is down  
Sending CDP packets every 60 seconds



Holdtime is 180 seconds  
GigabitEthernet1/1 is down, line protocol is down  
Sending CDP packets every 60 seconds  
Holdtime is 180 seconds  
GigabitEthernet1/2 is down, line protocol is down  
Sending CDP packets every 60 seconds  
Holdtime is 180 seconds

SW-2#sh cdp neighbors detail

Device ID: R-1

Entry address(es):

IP address : 192.168.1.100

Platform: cisco C2600, Capabilities: Router

Interface: FastEthernet0/1, Port ID (outgoing port): FastEthernet0/0

Holdtime: 125

Version :

Cisco Internetwork Operating System Software

IOS (tm) C2600 Software (C2600-I-M), Version 12.2(28), RELEASE SOFTWARE (fc5)

Technical Support: <http://www.cisco.com/techsupport>

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Compiled Wed 27-Apr-04 19:01 by miwang

advertisement version: 2

Duplex: full

-----  
Device ID: Switch

Entry address(es):

Platform: cisco 2950, Capabilities: Switch

Interface: FastEthernet0/22, Port ID (outgoing port): FastEthernet0/22

Holdtime: 46

Version :

Cisco Internetwork Operating System Software

IOS (tm) C2950 Software (C2950-I6Q4L2-M), Version 12.1(22)EA4, RELEASE SOFTWARE(fc1)

Copyright (c) 1986-2005 by cisco Systems, Inc.

Compiled Wed 18-May-05 22:31 by jharirba

advertisement version: 2

Duplex: full

-----  
Device ID: R-2

Entry address(es):

IP address : 192.168.2.100

Platform: cisco C1841, Capabilities: Router

Interface: FastEthernet0/2, Port ID (outgoing port): FastEthernet0/0

Holdtime: 129

Version :

Cisco IOS Software, 1841 Software (C1841-ADVIPSERVICESK9-M), Version 12.4(15)T1, RELEASE SOFTWARE (fc2)

Technical Support: <http://www.cisco.com/techsupport>

Copyright (c) 1986-2007 by Cisco Systems, Inc.

Compiled Wed 18-Jul-07 04:52 by pt\_team

advertisement version: 2

Duplex: full

-----  
**Device ID: R-3**

Entry address(es):

IP address : 192.168.3.100

Platform: cisco C2800, Capabilities: Router

Interface: FastEthernet0/3, Port ID (outgoing port): FastEthernet0/0

Holdtime: 150

Version :

Cisco IOS Software, 2800 Software (C2800NM-ADVIPSERVICESK9-M), Version 12.4(15)T1, RELEASE SOFTWARE (fc2)

Technical Support: <http://www.cisco.com/techsupport>

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Compiled Wed 18-Jul-07 06:21 by pt\_rel\_team

advertisement version: 2

Duplex: full

-----  
**Device ID: SW-1**

Entry address(es):

Platform: cisco 3560, Capabilities: Router

Interface: FastEthernet0/20, Port ID (outgoing port): FastEthernet0/20

Holdtime: 159

Version :

Cisco IOS Software, C3560 Software (C3560-ADVIPSERVICESK9-M), Version 12.2(37)SE1, RELEASE SOFTWARE (fc1)

Copyright (c) 1986-2007 by Cisco Systems, Inc.

Compiled Thu 05-Jul-07 22:22 by pt\_team

advertisement version: 2

Duplex: full

-----  
**Device ID: SW3**

Entry address(es):

Platform: cisco 2950, Capabilities: Switch

Interface: FastEthernet0/22, Port ID (outgoing port): FastEthernet0/22

Holdtime: 166

Version :

Cisco Internetwork Operating System Software

IOS (tm) C2950 Software (C2950-I6Q4L2-M), Version 12.1(22)EA4, RELEASE SOFTWARE(fc1)

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TASK: configure SW2 to Disable CDP

```
SW-2(config)#no cdp run
SW-2#sh cdp
% CDP is not enabled
```

TASK: configure SW2 to Enable CDP

```
SW-2(config)#cdp run
SW-2(config)#end
SW-2#sh cdp
Global CDP information:
 Sending CDP packets every 60 seconds
 Sending a holdtime value of 180 seconds
 Sending CDPv2 advertisements is enabled
```

```
SW-2(config)#int f0/20
SW-2(config-if)#no cdp enable
```

```
SW-2#sh cdp interface f0/20
```

```
SW-2#sh cdp interface f0/1
FastEthernet0/1 is up, line protocol is up
 Sending CDP packets every 60 seconds
 Holdtime is 180 seconds
```

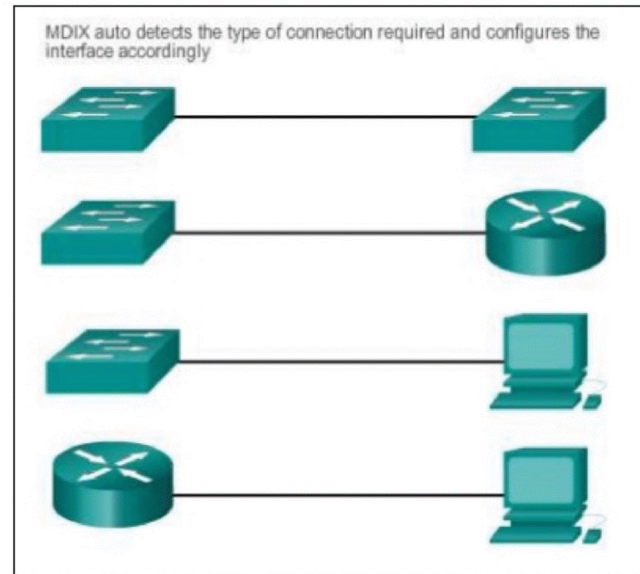
```
SW-2#sh cdp neighbors
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
 S - Switch, H - Host, I - IGMP, r - Repeater, P - Phone
Device ID Local Intrfce Holdtme Capability Platform Port ID
R-1 Fas 0/1 136 R C2600 Fas 0/0
R-2 Fas 0/2 140 R C1841 Fas 0/0
R-3 Fas 0/3 161 R C2800 Fas 0/0
SW3 Fas 0/22 177 S 2950 Fas 0/22
```



## Automatic medium-dependent interface crossover (Auto-MDIX)

- ▶ This feature automatically detects the required cable connection type (straight-through or crossover) for a connection.
- ▶ If one of the two sides of a connection supports auto-MDIX, a crossover or a straight-through Ethernet cable will work.
- ▶ This feature depends on the speed and duplex auto-negotiation feature being enabled.
- ▶ The default setting for auto-MDIX was changed from disabled to enabled with IOS Release 12.2(20)SE.

### Auto-MDIX



## To Configure (Auto-MDIX)

This feature manually enabled using the **mdix auto** command.

```
SW1(config)# interface FastEthernet 0/1
SW1(config-if)# shutdown
SW1(config-if)# speed auto
SW1(config-if)# duplex auto
SW1(config-if)# mdix auto
SW1(config-if)# no shutdown
SW1(config-if)# end
```

### Verify (Auto-MDIX)

```
SW1# show interface FastEthernet 0/1 transceiver properties
Diagnostic Monitoring is not implemented
Name : Fa0/1
Administrative Speed: auto
Administrative Duplex: auto
Administrative Auto-MDIX: on
Administrative Power Inline: N/A
Operational Speed: 100
Operational Duplex: full
Operational Auto-MDIX: on
Media Type: 10/100BaseTX
```

## Troubleshooting VLAN Issues

### Physical connectivity

- Sh Interface Status
- Sh ip interface Brief

### Same Network ( IP and Subnet Mask)

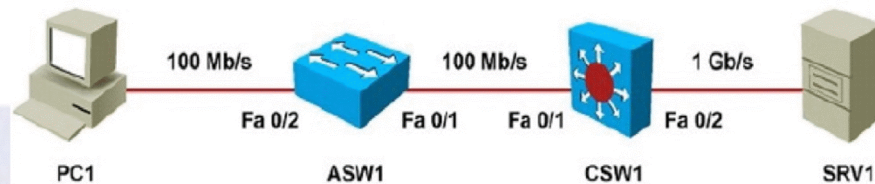
- Ipconfig (cmd)

### Make sure the hosts are in the correct VLAN.

- Sh vlan



## Troubleshooting Trunking



- ▶ Users to be on the Same vlan of both devices.
- ▶ Are the same VLANs permitted on both sides?
- ▶ Check Trunk configurations (Trunking configured or not)
- ▶ Are both sides of the link in the correct Trunking mode?

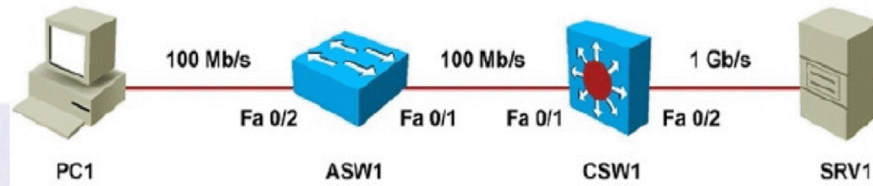
# Sh interface f0/20 switchport

- ▶ Is the same trunk encapsulation on both sides? (ISL/Dot1q)

# Sh interface Trunk



## Troubleshooting Trunking



SW1#sh interfaces trunk

| Port   | Mode                                                   | Encapsulation | Status   | Native vlan |
|--------|--------------------------------------------------------|---------------|----------|-------------|
| Fa0/24 | on                                                     | 802.1q        | trunking | 10          |
| Port   | Vlans allowed on trunk                                 |               |          |             |
| Fa0/24 | 10,20                                                  |               |          |             |
| Port   | Vlans allowed and active in management domain          |               |          |             |
| Fa0/24 | 10,20                                                  |               |          |             |
| Port   | Vlans in spanning tree forwarding state and not pruned |               |          |             |
| Fa0/24 | 10,20                                                  |               |          |             |

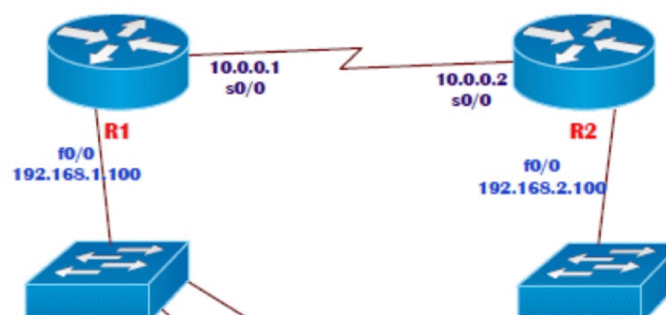
## Summary of all Issues that could cause the communication to fail:

- ▶ Physical problems
- ▶ Bad, missing, or miswired cables
- ▶ Bad ports
- ▶ Power failure
- ▶ Device problems
- ▶ Software bugs
- ▶ Performance problems
- ▶ Misconfiguration
- ▶ Missing or wrong VLANs
- ▶ Wrong VLAN setting on access ports
- ▶ Missing or misconfigured trunks
- ▶ VLANs not allowed on trunk



# TROUBLESHOOTING ROUTING

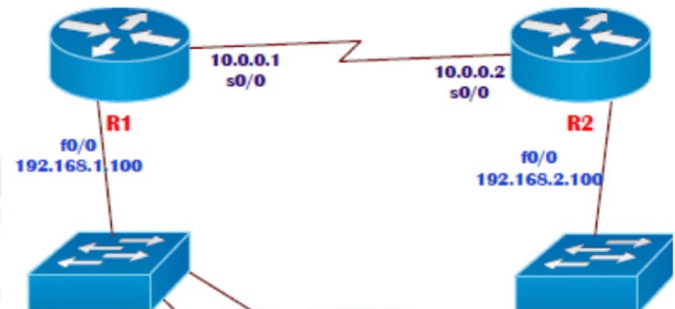
## Troubleshooting Connectivity



### R-1#show ip interface brief

| Interface       | IP-Address    | OK? | Method | Status                | Protocol |
|-----------------|---------------|-----|--------|-----------------------|----------|
| FastEthernet0/0 | 192.168.1.100 | YES | manual | up                    | up       |
| FastEthernet0/1 | unassigned    | YES | unset  | administratively down | down     |
| Serial0/0       | 10.0.0.1      | YES | manual | up                    | up       |
| Serial0/1       | unassigned    | YES | unset  | administratively down | down     |

# Troubleshooting Connectivity(contd)



## 1) Serial is up, line protocol is up

- Connectivity is fine.

## 2) Serial is down, line protocol is down

- remote device turned off
- remote port is in shutdown state
  - interface on the remote router has to be configured
- problem with connectivity

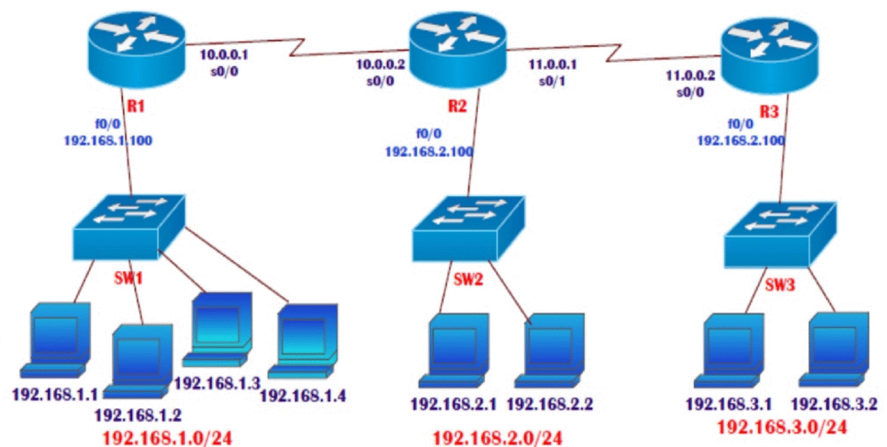
## 3) Serial is administratively down, line protocol is down

- local port is in shutdown state
  - No Shutdown has to be given on the local router interface

## 4) Serial is up, line protocol is down

- Encapsulation mismatch
- clock rate command not given on serial interface ( only applies in lab scenario )
- if using PPP , then authentication mismatch

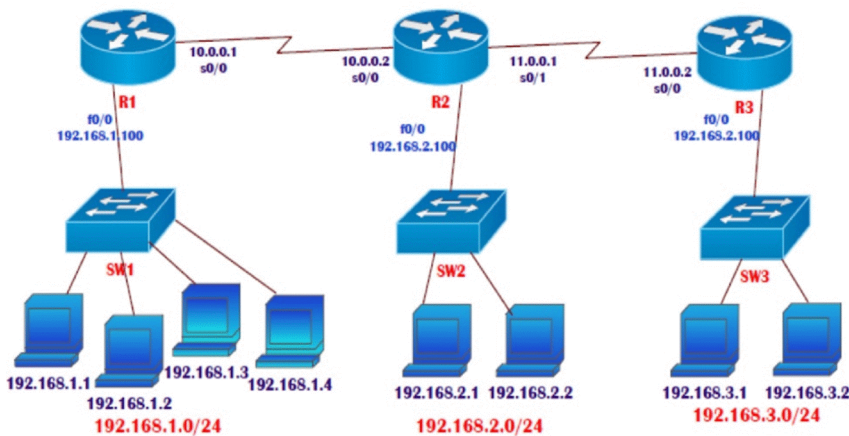
# Troubleshooting Routing



- ▶ Connectivity
- ▶ Understanding the Basic Routing Process
- ▶ Verifying the Routing Table for entry for destination
  - show ip route
- ▶ Verify the routing configurations
  - Sh running-config



## Troubleshooting Static & Default Routing



- Assuming all interfaces are UP UP

- Verifying the Routing Table for entry for destination.

show ip route

- Verify the routing configurations

Sh running-config

- Ensure that next hop is correct and is reachable. (both sides)
- Ensure that ACL is not dropping packets (traceroute)

## Trouble shooting OSPF:

### Connectivity between the routers (UP and UP)

- Ping connected interface
- Show ip int brief (UP UP)

### Osfp configurations

- Show ip ospf neighbor
- Show ip ospf int brief (interface /area)

### Neighbor issues

- Advertisements (Show ip ospf int brief , sh run | s ospf (interface /area)
- Area (show ip ospf int brief)
- Hello and dead (sh run int s1/0)

### ACL Drops the packet.

(traceroute/ sh run int f0/0)



## TroubleShooting EIGRP

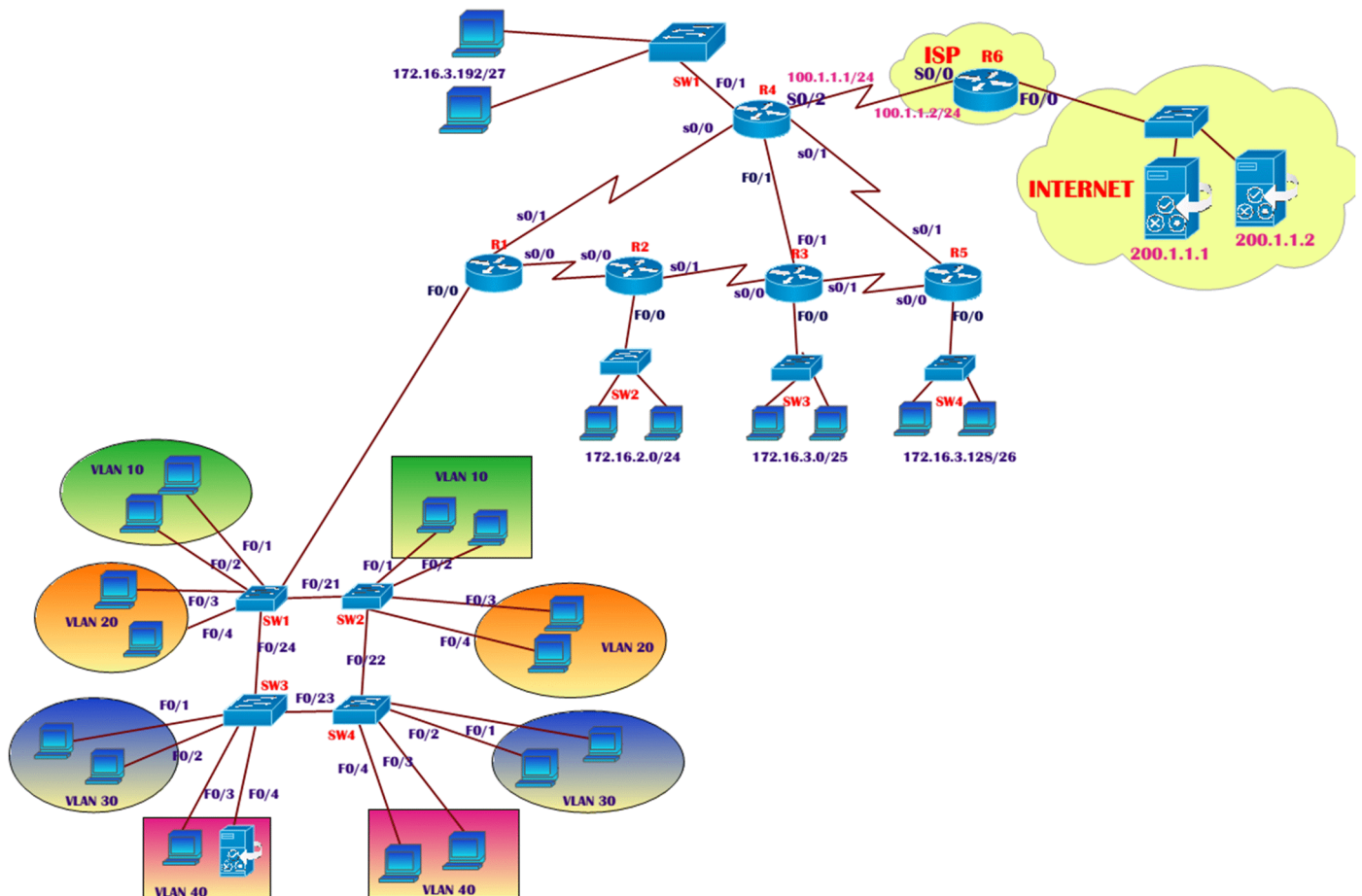
### Connectivity between the routers ( UP and UP )

- Ping connected interface
- Show ip int brief ( UP UP )

### EIGRP configurations

- verify neighbors hip
  - Advertisements ( show ip eigrp interfaces )
  - AS – no mismatch
  - Authentication
    - sh run int fo/o
    - Show key-chain
  - K-values ( sh run | s eigrp ) ( sh ip protocols )

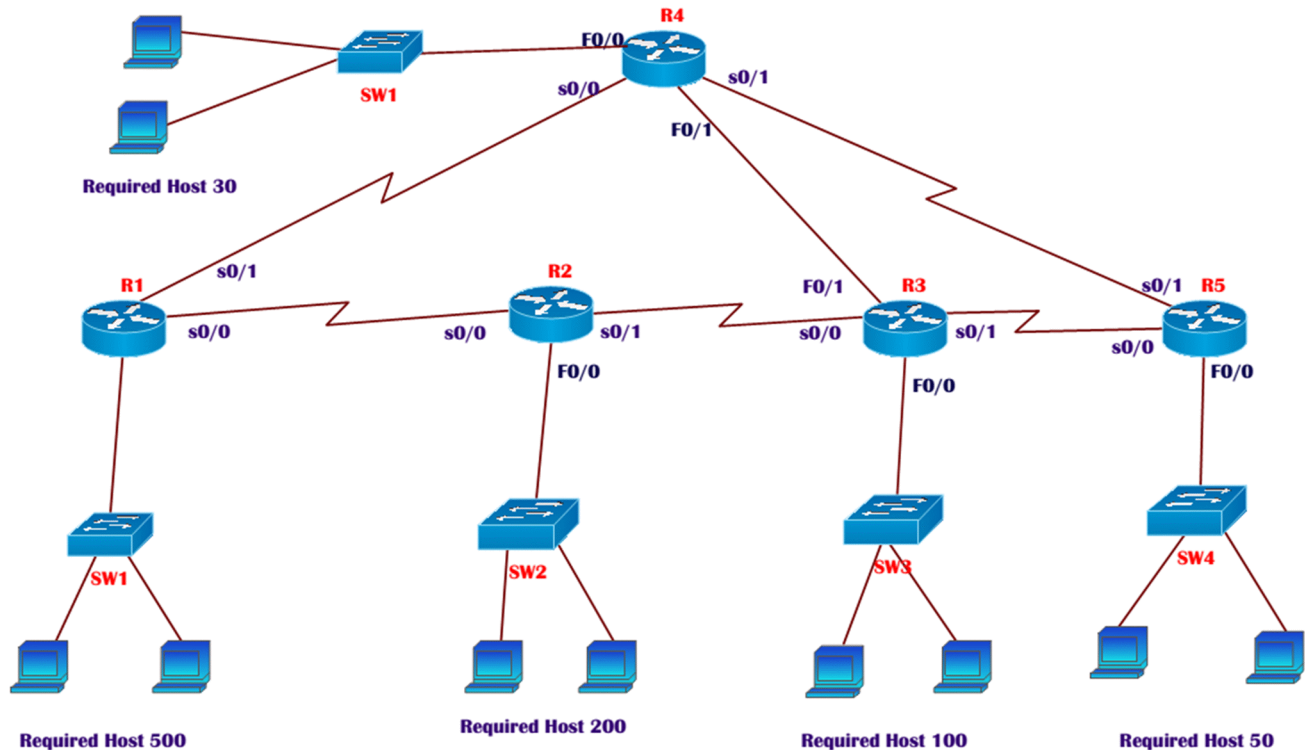
### ACL Drops the packet



NETWORK ONLINE ACADEMY

### TASK:

- Design the topology as per the Diagram.
- Assign the IP addressing on LAN and WAN interfaces using VLSM design (must use 172.16.0.0/16) network. Start with highest network requirement.
- Use the first IP of the range for all router interfaces.
- Ensure that connected interfaces of all routers should be able to ping each other.



```
R-1(config)#interface f0/0
R-1(config-if)# ip address 172.16.0.1 255.255.254.0
R-1(config-if)#no shutdown
R-1(config-if)#exit
```

```
R-1(config)#interface s0/0
R-1(config-if)# ip address 172.16.3.229 255.255.255.252
R-1(config-if)#no shutdown
R-1(config-if)#clock rate 64000
R-1(config-if)#exit
```

```
R-1(config)#interface serial 0/1
R-1(config-if)# ip address 172.16.3.225 255.255.255.252
R-1(config-if)#no shutdown
R-1(config-if)#clock rate 64000
R-1(config-if)#exit
```

```
R-1#sh ip int brief
```

| Interface       | IP-Address | OK? | Method | Status | Protocol |
|-----------------|------------|-----|--------|--------|----------|
| FastEthernet0/0 | 172.16.0.1 | YES | manual | up     | up       |



|                 |              |     |        |                       |      |
|-----------------|--------------|-----|--------|-----------------------|------|
| FastEthernet0/1 | unassigned   | YES | unset  | administratively down | down |
| Serial0/0       | 172.16.3.229 | YES | manual | down                  | down |
| Serial0/1       | 172.16.3.225 | YES | manual | down                  | down |

```
R-2(config)#interface f0/0
R-2(config-if)#ip address 172.16.2.1 255.255.255.0
R-2(config-if)#no shutdown
R-2(config-if)#exit
```

```
R-2(config)#interface serial 0/0
R-2(config-if)#ip address 172.16.3.230 255.255.255.252
R-2(config-if)#no shutdown
R-2(config-if)#exit
```

```
R-2(config)#interface serial 0/1
R-2(config-if)#ip address 172.16.3.233 255.255.255.252
R-2(config-if)#no shutdown
R-2(config-if)#clock rate 64000
R-2(config-if)#exit
```

R-2#sh ip int brief

| Interface       | IP-Address   | OK? | Method | Status                | Protocol |
|-----------------|--------------|-----|--------|-----------------------|----------|
| FastEthernet0/0 | 172.16.2.1   | YES | manual | up                    | up       |
| FastEthernet0/1 | unassigned   | YES | unset  | administratively down | down     |
| Serial0/0       | 172.16.3.230 | YES | manual | up                    | up       |
| Serial0/1       | 172.16.3.233 | YES | manual | down                  | down     |

R-2#

```
R-3(config)#interface f0/0
R-3(config-if)#ip address 172.16.3.1 255.255.255.128
R-3(config-if)#no shutdown
R-3(config-if)#exit
```

```
R-3(config)#interface s0/0
R-3(config-if)#ip address 172.16.3.234 255.255.255.252
R-3(config-if)#no shutdown
R-3(config-if)#exit
```

```
R-3(config)#interface serial 0/1
R-3(config-if)#ip address 172.16.3.237 255.255.255.252
R-3(config-if)#no shutdown
R-3(config-if)#clock rate 64000
R-3(config-if)#exit
```

```
R-3(config)#interface fastEthernet 0/1
R-3(config-if)#ip address 172.16.3.246 255.255.255.252
R-3(config-if)#no shutdown
R-3(config-if)# exit
```

R-3#sh ip int brief

| Interface | IP-Address | OK? | Method | Status | Protocol |
|-----------|------------|-----|--------|--------|----------|
|-----------|------------|-----|--------|--------|----------|

|                 |              |                 |      |
|-----------------|--------------|-----------------|------|
| FastEthernet0/0 | 172.16.3.1   | YES manual up   | up   |
| FastEthernet0/1 | 172.16.3.246 | YES manual up   | up   |
| Serial0/0       | 172.16.3.234 | YES manual up   | up   |
| Serial0/1       | 172.16.3.237 | YES manual down | down |

```
R-4(config)#interface fastEthernet 0/0
R-4(config-if)#ip address 172.16.3.193 255.255.255.224
R-4(config-if)#no shutdown
```

```
R-4(config)#interface s0/0
R-4(config-if)#ip address 172.16.3.226 255.255.255.252
R-4(config-if)#no shutdown
R-4(config-if)#exit
```

```
R-4(config)#interface s0/1
R-4(config-if)#ip address 172.16.3.241 255.255.255.252
R-4(config-if)#no shutdown
R-4(config-if)#clock rate 64000
R-4(config-if)#exit
```

```
R-4(config)#interface f0/1
R-4(config-if)#ip address 172.16.3.245 255.255.255.252
R-4(config-if)#no shutdown
R-4(config)#end
```

```
R-4#sh ip int brief
```

| Interface       | IP-Address   | OK? | Method | Status | Protocol |
|-----------------|--------------|-----|--------|--------|----------|
| FastEthernet0/0 | 172.16.3.193 | YES | manual | up     | up       |
| FastEthernet0/1 | 172.16.3.245 | YES | manual | up     | down     |
| Serial0/0       | 172.16.3.226 | YES | manual | up     | up       |
| Serial0/1       | 172.16.3.241 | YES | manual | down   | down     |

```
R-5(config)#interface fastEthernet 0/0
R-5(config-if)#ip address 172.16.3.129 255.255.255.192
R-5(config-if)#no shutdown
R-5(config)#exit
```

```
R-5(config)#interface serial 0/0
R-5(config-if)#ip address 172.16.3.238 255.255.255.252
R-5(config-if)#no shutdown
R-5(config-if)#exit
```

```
R-5(config)#interface serial 0/1
R-5(config-if)#ip address 172.16.3.242 255.255.255.252
R-5(config-if)#no shutdown
R-5(config-if)#exit
```

```
R-5#sh ip int brief
```

| Interface       | IP-Address   | OK? | Method | Status                | Protocol |
|-----------------|--------------|-----|--------|-----------------------|----------|
| FastEthernet0/0 | 172.16.3.129 | YES | manual | up                    | up       |
| FastEthernet0/1 | unassigned   | YES | unset  | administratively down | down     |

|           |              |               |    |
|-----------|--------------|---------------|----|
| Serial0/0 | 172.16.3.238 | YES manual up | up |
| Serial0/1 | 172.16.3.242 | YES manual up | up |

R-5#ping 172.16.3.237

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 172.16.3.237, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/5 ms

R-5#ping 172.16.3.241

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 172.16.3.241, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/8 ms

R-4#ping 172.16.3.246

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 172.16.3.246, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 0/0/0 ms

R-4#ping 172.16.3.225

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 172.16.3.225, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/8 ms

R-3#ping 172.16.3.233

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 172.16.3.233, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/9 ms

R-2#ping 172.16.3.229

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 172.16.3.229, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/7/33 ms

PC>ipconfig

FastEthernet0 Connection:(default port)

Link-local IPv6 Address.....: FE80::203:E4FF:FE9B:E9AE

IP Address.....: 172.16.0.2

Subnet Mask.....: 255.255.254.0

Default Gateway.....: 172.16.0.1

PC>ping 172.16.0.1

Pinging 172.16.0.1 with 32 bytes of data:

Reply from 172.16.0.1: bytes=32 time=1ms TTL=255

Reply from 172.16.0.1: bytes=32 time=0ms TTL=255



Reply from 172.16.0.1: bytes=32 time=0ms TTL=255  
Reply from 172.16.0.1: bytes=32 time=0ms TTL=255  
Ping statistics for 172.16.0.1:  
Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),  
Approximate round trip times in milli-seconds:  
Minimum = 0ms, Maximum = 1ms, Average = 0ms

PC>ping 172.16.0.3

Pinging 172.16.0.3 with 32 bytes of data:

Reply from 172.16.0.3: bytes=32 time=1ms TTL=128  
Reply from 172.16.0.3: bytes=32 time=0ms TTL=128  
Reply from 172.16.0.3: bytes=32 time=0ms TTL=128  
Reply from 172.16.0.3: bytes=32 time=0ms TTL=128

Ping statistics for 172.16.0.3:  
Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),  
Approximate round trip times in milli-seconds:  
Minimum = 0ms, Maximum = 1ms, Average = 0ms

PC>ipconfig

FastEthernet0 Connection:(default port)  
Link-local IPv6 Address.....: FE80::20A:41FF:FE67:1977  
IP Address.....: 172.16.2.2  
Subnet Mask.....: 255.255.255.0  
Default Gateway.....: 172.16.2.1

PC>ping 172.16.2.1

Pinging 172.16.2.1 with 32 bytes of data:  
Reply from 172.16.2.1: bytes=32 time=1ms TTL=255  
Reply from 172.16.2.1: bytes=32 time=0ms TTL=255  
Reply from 172.16.2.1: bytes=32 time=0ms TTL=255  
Reply from 172.16.2.1: bytes=32 time=0ms TTL=255

Ping statistics for 172.16.2.1:  
Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),  
Approximate round trip times in milli-seconds:  
Minimum = 0ms, Maximum = 1ms, Average = 0ms

PC>ping 172.16.2.3

Pinging 172.16.2.3 with 32 bytes of data:

Reply from 172.16.2.3: bytes=32 time=1ms TTL=128  
Reply from 172.16.2.3: bytes=32 time=0ms TTL=128  
Reply from 172.16.2.3: bytes=32 time=0ms TTL=128  
Reply from 172.16.2.3: bytes=32 time=0ms TTL=128  
Ping statistics for 172.16.2.3:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),  
Approximate round trip times in milli-seconds:  
Minimum = 0ms, Maximum = 1ms, Average = 0ms

PC>ipconfig

FastEthernet0 Connection:(default port)  
Link-local IPv6 Address.....: FE80::230:F2FF:FEAC:BB83  
IP Address.....: 172.16.3.2  
Subnet Mask.....: 255.255.255.128  
Default Gateway.....: 172.16.3.1

PC>ping 172.16.3.1

Pinging 172.16.3.1 with 32 bytes of data:

Reply from 172.16.3.1: bytes=32 time=1ms TTL=255  
Reply from 172.16.3.1: bytes=32 time=0ms TTL=255  
Reply from 172.16.3.1: bytes=32 time=0ms TTL=255  
Reply from 172.16.3.1: bytes=32 time=0ms TTL=255

Ping statistics for 172.16.3.1:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),  
Approximate round trip times in milli-seconds:  
Minimum = 0ms, Maximum = 1ms, Average = 0ms

PC>ping 172.16.3.3

Pinging 172.16.3.3 with 32 bytes of data:

Reply from 172.16.3.3: bytes=32 time=0ms TTL=128  
Reply from 172.16.3.3: bytes=32 time=0ms TTL=128  
Reply from 172.16.3.3: bytes=32 time=0ms TTL=128  
Reply from 172.16.3.3: bytes=32 time=0ms TTL=128

Ping statistics for 172.16.3.3:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),  
Approximate round trip times in milli-seconds:  
Minimum = 0ms, Maximum = 0ms, Average = 0ms

PC>ipconfig

FastEthernet0 Connection:(default port)  
Link-local IPv6 Address.....: FE80::201:96FF:FE77:DA66  
IP Address.....: 172.16.3.130  
Subnet Mask.....: 255.255.255.192  
Default Gateway.....: 172.16.3.129

PC>ping 172.16.3.129

Pinging 172.16.3.129 with 32 bytes of data:

Reply from 172.16.3.129: bytes=32 time=1ms TTL=255  
Reply from 172.16.3.129: bytes=32 time=0ms TTL=255  
Reply from 172.16.3.129: bytes=32 time=0ms TTL=255  
Reply from 172.16.3.129: bytes=32 time=0ms TTL=255

Ping statistics for 172.16.3.129:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),  
Approximate round trip times in milli-seconds:  
Minimum = 0ms, Maximum = 1ms, Average = 0ms

PC>ping 172.16.3.131

Pinging 172.16.3.131 with 32 bytes of data:

Reply from 172.16.3.131: bytes=32 time=2ms TTL=128

Reply from 172.16.3.131: bytes=32 time=0ms TTL=128

Reply from 172.16.3.131: bytes=32 time=0ms TTL=128

Reply from 172.16.3.131: bytes=32 time=0ms TTL=128

PC>ipconfig

FastEthernet0 Connection:(default port)

Link-local IPv6 Address.....: FE80::290:CFF:FE08:9949

IP Address.....: 172.16.3.194

Subnet Mask.....: 255.255.255.224

Default Gateway.....: 172.16.3.193

PC>ping 172.16.3.193

Pinging 172.16.3.193 with 32 bytes of data:

Reply from 172.16.3.193: bytes=32 time=1ms TTL=255

Reply from 172.16.3.193: bytes=32 time=1ms TTL=255

Reply from 172.16.3.193: bytes=32 time=0ms TTL=255

Reply from 172.16.3.193: bytes=32 time=16ms TTL=255

PC>ping 172.16.3.195

Pinging 172.16.3.195 with 32 bytes of data:

Reply from 172.16.3.195: bytes=32 time=1ms TTL=128

Reply from 172.16.3.195: bytes=32 time=0ms TTL=128

Reply from 172.16.3.195: bytes=32 time=0ms TTL=128

Reply from 172.16.3.195: bytes=32 time=1ms TTL=128

#### TASK:

- Configure PPP protocol on R1-R2 & R1-R4
- use PPP CHAP authentication between R1-R2
- use PPP PAP authentication between R1-R4
- Ensure that the interfaces are UP UP

R-1(config)#username R-2 password cisco123

R-1(config)#interface serial 0/0

R-1(config-if)#encapsulation ppp

R-1(config-if)#ppp authentication chap

R-1(config-if)#exit

R-2(config)#username R-1 password cisco123

R-2(config)#interface serial 0/0

R-2(config-if)#encapsulation ppp

R-2(config-if)#ppp authentication chap

R-2(config-if)#exit



R-2#sh ip int brief

| Interface       | IP-Address   | OK? | Method | Status                | Protocol |
|-----------------|--------------|-----|--------|-----------------------|----------|
| FastEthernet0/0 | 172.16.2.1   | YES | manual | up                    | up       |
| FastEthernet0/1 | unassigned   | YES | unset  | administratively down | down     |
| Serial0/0       | 172.16.3.230 | YES | manual | up                    | up       |
| Serial0/1       | 172.16.3.233 | YES | manual | up                    | up       |

R-2#ping 172.16.3.229

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 172.16.3.229, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/7/15 ms

R-1(config)#username R-4 password cisco123

R-1(config)#interface serial 0/1

R-1(config-if)#encapsulation ppp

R-1(config-if)#ppp authentication pap

R-1(config-if)#ppp pap sent-username R-1 password cisco123

R-1(config-if)#end

R-4(config)#username R-1 password cisco123

R-4(config)#interface serial 0/1

R-4(config-if)#encapsulation ppp

R-4(config-if)#ppp authentication pap

R-4(config-if)#ppp pap sent-username R-4 password cisco123

R-4(config-if)#exit

R-4(config)#interface serial 0/0

R-4(config-if)#encapsulation ppp

R-4(config-if)# ppp authentication pap

R-4(config-if)# ppp pap sent-username R-4 password cisco123

R-4(config-if)# exit

R-4(config)#end

R-4#sh ip interface brief

| Interface       | IP-Address   | OK? | Method | Status | Protocol |
|-----------------|--------------|-----|--------|--------|----------|
| FastEthernet0/0 | 172.16.3.193 | YES | manual | up     | up       |
| FastEthernet0/1 | 172.16.3.245 | YES | manual | up     | up       |
| Serial0/0       | 172.16.3.226 | YES | manual | up     | up       |
| Serial0/1       | 172.16.3.241 | YES | manual | up     | up       |

R-4#

R-4#ping 172.16.3.225

Type escape sequence to abort.

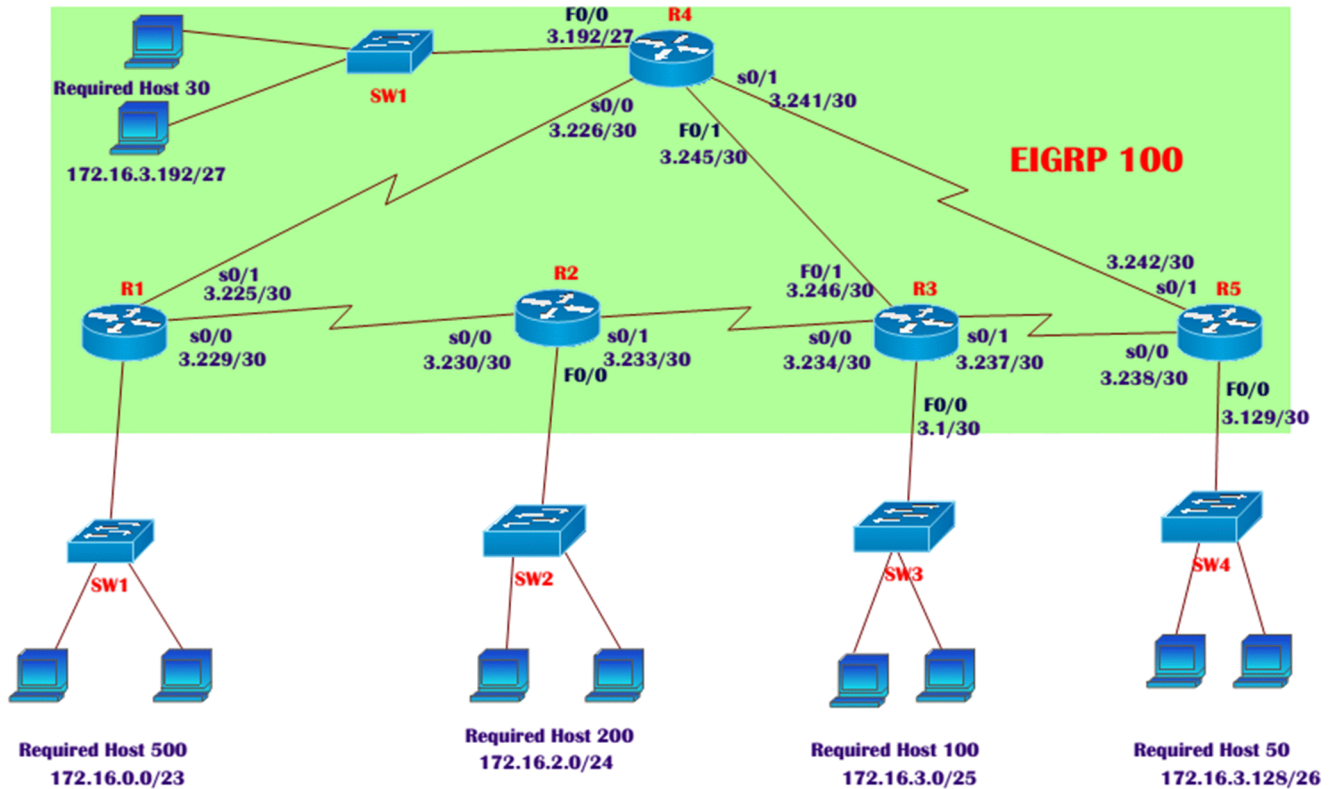
Sending 5, 100-byte ICMP Echos to 172.16.3.225, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/7/19 ms

### TASK:

- Configure EIGRP 100 on all routers.
- Find the best path used by EIGRP to reach from R1- R5, R1-R3.



### On all routers

```
R-x(config)# router eigrp 100
R-x(config-router)# network 172.16.0.0
R-x(config-router)# exit
```

### R-5#sh ip eigrp neighbors

IP-EIGRP neighbors for process 100

| H | Address      | Interface | Hold (sec) | Uptime (ms) | SRTT Cnt | RTO Num | Q | Seq |
|---|--------------|-----------|------------|-------------|----------|---------|---|-----|
| 0 | 172.16.3.237 | Se0/0     | 14         | 00:00:17    | 40       | 1000    | 0 | 21  |
| 1 | 172.16.3.241 | Se0/1     | 14         | 00:00:17    | 40       | 1000    | 0 | 23  |

### R-4#sh ip eigrp neighbors

IP-EIGRP neighbors for process 100

| H | Address      | Interface | Hold (sec) | Uptime (ms) | SRTT Cnt | RTO Num | Q | Seq |
|---|--------------|-----------|------------|-------------|----------|---------|---|-----|
| 0 | 172.16.3.246 | Fa0/1     | 10         | 00:01:46    | 40       | 1000    | 0 | 36  |
| 1 | 172.16.3.242 | Se0/1     | 13         | 00:01:38    | 40       | 1000    | 0 | 46  |
| 2 | 172.16.3.225 | Se0/0     | 13         | 00:00:34    | 40       | 1000    | 0 | 62  |

### R-2#sh ip eigrp neighbors

IP-EIGRP neighbors for process 100

| H | Address      | Interface | Hold (sec) | Uptime (ms) | SRTT Cnt | RTT Num | Q | Seq |
|---|--------------|-----------|------------|-------------|----------|---------|---|-----|
| 0 | 172.16.3.234 | Se0/1     | 14         | 00:02:03    | 40       | 1000    | 0 | 35  |
| 1 | 172.16.3.229 | Se0/0     | 10         | 00:00:59    | 40       | 1000    | 0 | 61  |

R-2#sh ip route eigrp

172.16.0.0/16 is variably subnetted, 12 subnets, 7 masks

|   |                 |              |                                       |
|---|-----------------|--------------|---------------------------------------|
| D | 172.16.0.0/23   | [90/2172416] | via 172.16.3.229, 00:01:06, Serial0/0 |
| D | 172.16.3.0/25   | [90/2172416] | via 172.16.3.234, 00:02:10, Serial0/1 |
| D | 172.16.3.128/26 | [90/2684416] | via 172.16.3.234, 00:02:10, Serial0/1 |
| D | 172.16.3.192/27 | [90/2174976] | via 172.16.3.234, 00:02:10, Serial0/1 |
| D | 172.16.3.224/30 | [90/2681856] | via 172.16.3.229, 00:01:06, Serial0/0 |
| D | 172.16.3.236/30 | [90/2681856] | via 172.16.3.234, 00:02:10, Serial0/1 |
| D | 172.16.3.240/30 | [90/2684416] | via 172.16.3.234, 00:02:10, Serial0/1 |
| D | 172.16.3.244/30 | [90/2172416] | via 172.16.3.234, 00:02:10, Serial0/1 |

R-1#sh ip route eigrp

172.16.0.0/16 is variably subnetted, 13 subnets, 7 masks

|   |                 |              |                                       |
|---|-----------------|--------------|---------------------------------------|
| D | 172.16.2.0/24   | [90/2172416] | via 172.16.3.230, 00:03:04, Serial0/0 |
| D | 172.16.3.0/25   | [90/2174976] | via 172.16.3.226, 00:03:04, Serial0/1 |
| D | 172.16.3.128/26 | [90/2684416] | via 172.16.3.226, 00:03:04, Serial0/1 |
| D | 172.16.3.192/27 | [90/2172416] | via 172.16.3.226, 00:03:04, Serial0/1 |
| D | 172.16.3.232/30 | [90/2681856] | via 172.16.3.230, 00:03:04, Serial0/0 |
| D | 172.16.3.236/30 | [90/2684416] | via 172.16.3.226, 00:03:04, Serial0/1 |
| D | 172.16.3.240/30 | [90/2681856] | via 172.16.3.226, 00:03:04, Serial0/1 |
| D | 172.16.3.244/30 | [90/2172416] | via 172.16.3.226, 00:03:04, Serial0/1 |

R-1#traceroute 172.16.3.129

Type escape sequence to abort.

Tracing the route to 172.16.3.129

|   |              |        |         |        |
|---|--------------|--------|---------|--------|
| 1 | 172.16.3.226 | 0 msec | 0 msec  | 1 msec |
| 2 | 172.16.3.242 | 1 msec | 15 msec | 2 msec |

R-2#sh ip route eigrp

172.16.0.0/16 is variably subnetted, 12 subnets, 7 masks

|   |                 |              |                                       |
|---|-----------------|--------------|---------------------------------------|
| D | 172.16.0.0/23   | [90/2172416] | via 172.16.3.229, 00:04:04, Serial0/0 |
| D | 172.16.3.0/25   | [90/2172416] | via 172.16.3.234, 00:05:08, Serial0/1 |
| D | 172.16.3.128/26 | [90/2684416] | via 172.16.3.234, 00:05:08, Serial0/1 |
| D | 172.16.3.192/27 | [90/2174976] | via 172.16.3.234, 00:05:08, Serial0/1 |
| D | 172.16.3.224/30 | [90/2681856] | via 172.16.3.229, 00:04:04, Serial0/0 |
| D | 172.16.3.236/30 | [90/2681856] | via 172.16.3.234, 00:05:08, Serial0/1 |
| D | 172.16.3.240/30 | [90/2684416] | via 172.16.3.234, 00:05:08, Serial0/1 |
| D | 172.16.3.244/30 | [90/2172416] | via 172.16.3.234, 00:05:08, Serial0/1 |

R-2#traceroute 172.16.3.129

Type escape sequence to abort.

Tracing the route to 172.16.3.129

|   |              |        |        |        |
|---|--------------|--------|--------|--------|
| 1 | 172.16.3.234 | 2 msec | 0 msec | 2 msec |
|---|--------------|--------|--------|--------|



2 172.16.3.238 15 msec 0 msec 1 msec

## R-2#sh ip eigrp topology

IP-EIGRP Topology Table for AS 100

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,  
r - Reply status

P 172.16.2.0/24, 1 successors, FD is 28160  
via Connected, FastEthernet0/0  
P 172.16.3.232/30, 1 successors, FD is 2169856  
via Connected, Serial0/1  
P 172.16.3.228/30, 1 successors, FD is 2169856  
via Connected, Serial0/0  
P 172.16.3.224/30, 1 successors, FD is 2681856  
via 172.16.3.229 (2681856/2169856), Serial0/0  
via 172.16.3.234 (2684416/2172416), Serial0/1  
P 172.16.3.244/30, 1 successors, FD is 2172416  
via 172.16.3.234 (2172416/28160), Serial0/1  
P 172.16.3.192/27, 1 successors, FD is 2174976  
via 172.16.3.234 (2174976/30720), Serial0/1  
via 172.16.3.229 (2684416/2172416), Serial0/0  
P 172.16.3.240/30, 1 successors, FD is 2684416  
via 172.16.3.234 (2684416/2172416), Serial0/1  
via 172.16.3.229 (3193856/2681856), Serial0/0  
P 172.16.3.0/25, 1 successors, FD is 2172416  
via 172.16.3.234 (2172416/28160), Serial0/1  
P 172.16.3.236/30, 1 successors, FD is 2681856  
via 172.16.3.234 (2681856/2169856), Serial0/1  
P 172.16.3.128/26, 1 successors, FD is 2684416  
via 172.16.3.234 (2684416/2172416), Serial0/1  
P 172.16.0.0/23, 1 successors, FD is 2172416  
via 172.16.3.229 (2172416/28160), Serial0/0

## R-3#sh ip eigrp topology

IP-EIGRP Topology Table for AS 100

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,  
r - Reply status

P 172.16.3.244/30, 1 successors, FD is 28160  
via Connected, FastEthernet0/1  
P 172.16.3.0/25, 1 successors, FD is 28160  
via Connected, FastEthernet0/0  
P 172.16.3.236/30, 1 successors, FD is 2169856  
via Connected, Serial0/1  
P 172.16.3.192/27, 1 successors, FD is 30720  
via 172.16.3.245 (30720/28160), FastEthernet0/1  
P 172.16.3.240/30, 1 successors, FD is 2172416  
via 172.16.3.245 (2172416/2169856), FastEthernet0/1  
via 172.16.3.238 (2681856/2169856), Serial0/1

```

P 172.16.3.128/26, 1 successors, FD is 2172416
 via 172.16.3.238 (2172416/28160), Serial0/1
P 172.16.3.224/30, 1 successors, FD is 2172416
 via 172.16.3.245 (2172416/2169856), FastEthernet0/1
P 172.16.3.228/30, 1 successors, FD is 2681856
 via 172.16.3.233 (2681856/2169856), Serial0/0
P 172.16.2.0/24, 1 successors, FD is 2172416
 via 172.16.3.233 (2172416/28160), Serial0/0
P 172.16.3.232/30, 1 successors, FD is 2169856
 via Connected, Serial0/0
P 172.16.0.0/23, 1 successors, FD is 2174976
 via 172.16.3.245 (2174976/2172416), FastEthernet0/1
 via 172.16.3.233 (2684416/2172416), Serial0/0

```

### R-3#sh ip route eigrp

```

172.16.0.0/16 is variably subnetted, 11 subnets, 6 masks
D 172.16.0.0/23 [90/2174976] via 172.16.3.245, 00:05:18, FastEthernet0/1
D 172.16.2.0/24 [90/2172416] via 172.16.3.233, 00:06:22, Serial0/0
D 172.16.3.128/26 [90/2172416] via 172.16.3.238, 00:06:25, Serial0/1
D 172.16.3.192/27 [90/30720] via 172.16.3.245, 00:06:30, FastEthernet0/1
D 172.16.3.224/30 [90/2172416] via 172.16.3.245, 00:06:24, FastEthernet0/1
D 172.16.3.228/30 [90/2681856] via 172.16.3.233, 00:06:22, Serial0/0
D 172.16.3.240/30 [90/2172416] via 172.16.3.245, 00:06:30, FastEthernet0/1

```

### R-3#sh ip route eigrp

```

172.16.0.0/16 is variably subnetted, 11 subnets, 6 masks
D 172.16.0.0/23 [90/2174976] via 172.16.3.245, 00:05:29, FastEthernet0/1
D 172.16.2.0/24 [90/2172416] via 172.16.3.233, 00:06:32, Serial0/0
D 172.16.3.128/26 [90/2172416] via 172.16.3.238, 00:06:36, Serial0/1
D 172.16.3.192/27 [90/30720] via 172.16.3.245, 00:06:40, FastEthernet0/1
D 172.16.3.224/30 [90/2172416] via 172.16.3.245, 00:06:34, FastEthernet0/1
D 172.16.3.228/30 [90/2681856] via 172.16.3.233, 00:06:32, Serial0/0
D 172.16.3.240/30 [90/2172416] via 172.16.3.245, 00:06:40, FastEthernet0/1

```

### R-3#traceroute 172.16.3.129

```

Type escape sequence to abort.
Tracing the route to 172.16.3.129

```

```

 1 172.16.3.238 3 msec 1 msec 0 msec

```

### R-3#traceroute 172.16.0.1

```

Type escape sequence to abort.
Tracing the route to 172.16.0.1

```

```

 1 172.16.3.245 0 msec 0 msec 0 msec
 2 172.16.3.225 2 msec 2 msec 2 msec

```

### TASK:

- By default the traffic between R1 to R5 has three possible paths.
- Change BW on R1 S0/1 to 1000 Kbps assuming its the BW given by provider instead of using default
- Check if changes to alternate route.

R-1#sh ip route eigrp

172.16.0.0/16 is variably subnetted, 13 subnets, 7 masks

```
D 172.16.2.0/24 [90/2172416] via 172.16.3.230, 01:20:43, Serial0/0
D 172.16.3.0/25 [90/2174976] via 172.16.3.226, 01:20:43, Serial0/1
D 172.16.3.128/26 [90/2684416] via 172.16.3.226, 01:20:43, Serial0/1
D 172.16.3.192/27 [90/2172416] via 172.16.3.226, 01:20:43, Serial0/1
D 172.16.3.232/30 [90/2681856] via 172.16.3.230, 01:20:43, Serial0/0
D 172.16.3.236/30 [90/2684416] via 172.16.3.226, 01:20:43, Serial0/1
D 172.16.3.240/30 [90/2681856] via 172.16.3.226, 01:20:43, Serial0/1
D 172.16.3.244/30 [90/2172416] via 172.16.3.226, 01:20:43, Serial0/1
```

R-1#traceroute 172.16.3.129

Type escape sequence to abort.

Tracing the route to 172.16.3.129

```
 1 172.16.3.226 4 msec 2 msec 0 msec
 2 172.16.3.242 1 msec 2 msec 1 msec
```

R-1#sh interfaces s0/1

Serial0/1 is up, line protocol is up (connected)

Hardware is HD64570

Internet address is 172.16.3.225/30

MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,  
reliability 255/255, txload 1/255, rxload 1/255

Encapsulation PPP, loopback not set, keepalive set (10 sec)

LCP Open

Open: IPCP, CDPCP

Last input never, output never, output hang never

Last clearing of "show interface" counters never

Input queue: 0/75/0 (size/max/drops); Total output drops: 0

Queueing strategy: weighted fair

Output queue: 0/1000/64/0 (size/max total/threshold/drops)

Conversations 0/0/256 (active/max active/max total)

Reserved Conversations 0/0 (allocated/max allocated)

Available Bandwidth 1158 kilobits/sec

5 minute input rate 108 bits/sec, 0 packets/sec

5 minute output rate 105 bits/sec, 0 packets/sec

1141 packets input, 68408 bytes, 0 no buffer

Received 0 broadcasts, 0 runs, 0 giants, 0 throttles

0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort

1106 packets output, 66042 bytes, 0 underruns

0 output errors, 0 collisions, 1 interface resets

0 output buffer failures, 0 output buffers swapped out

0 carrier transitions

DCD=up DSR=up DTR=up RTS=up CTS=up

R-1(config)#interface serial 0/1

R-1(config-if)#bandwidth 1000

R-1(config-if)#end

R-4(config)#interface s0/0



R-4(config-if)#bandwidth 1000

R-4(config-if)#end

R-1#sh ip route eigrp

172.16.0.0/16 is variably subnetted, 13 subnets, 7 masks

D 172.16.2.0/24 [90/2172416] via 172.16.3.230, 01:21:32, Serial0/0  
D 172.16.3.0/25 [90/2684416] via 172.16.3.230, 01:21:32, Serial0/0  
D 172.16.3.128/26 [90/3196416] via 172.16.3.230, 00:00:15, Serial0/0  
D 172.16.3.192/27 [90/2686976] via 172.16.3.230, 00:00:15, Serial0/0  
D 172.16.3.232/30 [90/2681856] via 172.16.3.230, 01:21:32, Serial0/0  
D 172.16.3.236/30 [90/3193856] via 172.16.3.230, 01:21:32, Serial0/0  
D 172.16.3.240/30 [90/3196416] via 172.16.3.230, 00:00:15, Serial0/0  
D 172.16.3.244/30 [90/2684416] via 172.16.3.230, 00:00:15, Serial0/0

R-1#sh ip eigrp topology

IP-EIGRP Topology Table for AS 100

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,  
r - Reply status

P 172.16.0.0/23, 1 successors, FD is 28160  
via Connected, FastEthernet0/0  
P 172.16.3.228/30, 1 successors, FD is 2169856  
via Connected, Serial0/0  
P 172.16.3.224/30, 1 successors, FD is 3072000  
via Connected, Serial0/1  
P 172.16.2.0/24, 1 successors, FD is 2172416  
via 172.16.3.230 (2172416/28160), Serial0/0  
P 172.16.3.232/30, 1 successors, FD is 2681856  
via 172.16.3.230 (2681856/2169856), Serial0/0  
via 172.16.3.226 (3586560/2172416), Serial0/1  
P 172.16.3.244/30, 1 successors, FD is 2684416  
via 172.16.3.230 (2684416/2172416), Serial0/0  
via 172.16.3.226 (3074560/28160), Serial0/1  
P 172.16.3.192/27, 1 successors, FD is 2686976  
via 172.16.3.230 (2686976/2174976), Serial0/0  
via 172.16.3.226 (3074560/28160), Serial0/1  
P 172.16.3.240/30, 1 successors, FD is 3196416  
via 172.16.3.230 (3196416/2684416), Serial0/0  
via 172.16.3.226 (3584000/2169856), Serial0/1  
P 172.16.3.0/25, 1 successors, FD is 2684416  
via 172.16.3.230 (2684416/2172416), Serial0/0  
via 172.16.3.226 (3077120/30720), Serial0/1  
P 172.16.3.236/30, 1 successors, FD is 3193856  
via 172.16.3.230 (3193856/2681856), Serial0/0  
via 172.16.3.226 (3586560/2172416), Serial0/1  
P 172.16.3.128/26, 1 successors, FD is 3196416  
via 172.16.3.230 (3196416/2684416), Serial0/0  
via 172.16.3.226 (3586560/2172416), Serial0/1

R-1#traceroute 172.16.3.129

Type escape sequence to abort.  
Tracing the route to 172.16.3.129

|   |              |         |        |        |
|---|--------------|---------|--------|--------|
| 1 | 172.16.3.230 | 12 msec | 2 msec | 0 msec |
| 2 | 172.16.3.234 | 0 msec  | 0 msec | 2 msec |
| 3 | 172.16.3.238 | 2 msec  | 3 msec | 3 msec |

#### **TASK:**

- **Remove EIGRP and bandwidth configured on R1-R4 interfaces.**

On all routers

```
R-x(config)#no router eigrp 100
R-x(config)#end
```

```
R-1(config)#int s0/1
R-1(config-if)#no bandwidth 1000
R-1(config-if)#exit
```

R-1#sh interfaces serial 0/1

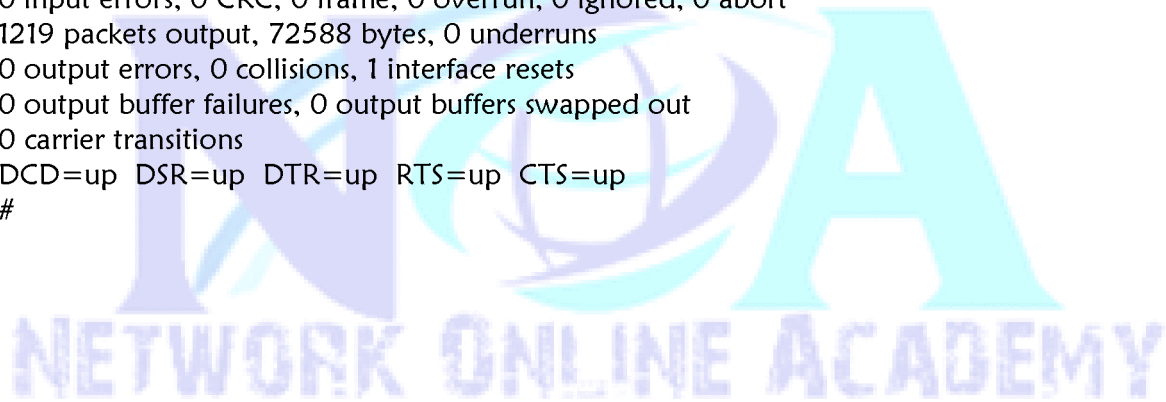
```
Serial0/1 is up, line protocol is up (connected)
Hardware is HD64570
Internet address is 172.16.3.225/30
MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
 reliability 255/255, txload 1/255, rxload 1/255
Encapsulation PPP, loopback not set, keepalive set (10 sec)
LCP Open
Open: IPCP, CDPCP
Last input never, output never, output hang never
Last clearing of "show interface" counters never
Input queue: 0/75/0 (size/max/drops); Total output drops: 0
Queueing strategy: weighted fair
Output queue: 0/1000/64/0 (size/max total/threshold/drops)
 Conversations 0/0/256 (active/max active/max total)
 Reserved Conversations 0/0 (allocated/max allocated)
 Available Bandwidth 1158 kilobits/sec
5 minute input rate 32 bits/sec, 0 packets/sec
5 minute output rate 15 bits/sec, 0 packets/sec
1233 packets input, 74350 bytes, 0 no buffer
Received 1 broadcasts, 0 runts, 0 giants, 0 throttles
0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
1182 packets output, 70489 bytes, 0 underruns
0 output errors, 0 collisions, 1 interface resets
0 output buffer failures, 0 output buffers swapped out
0 carrier transitions
DCD=up DSR=up DTR=up RTS=up CTS=up
```

```
R-4(config)#int s0/0
R-4(config-if)#no bandwidth 1000
R-4(config-if)#end
```

R-4#sh interfaces s0/0

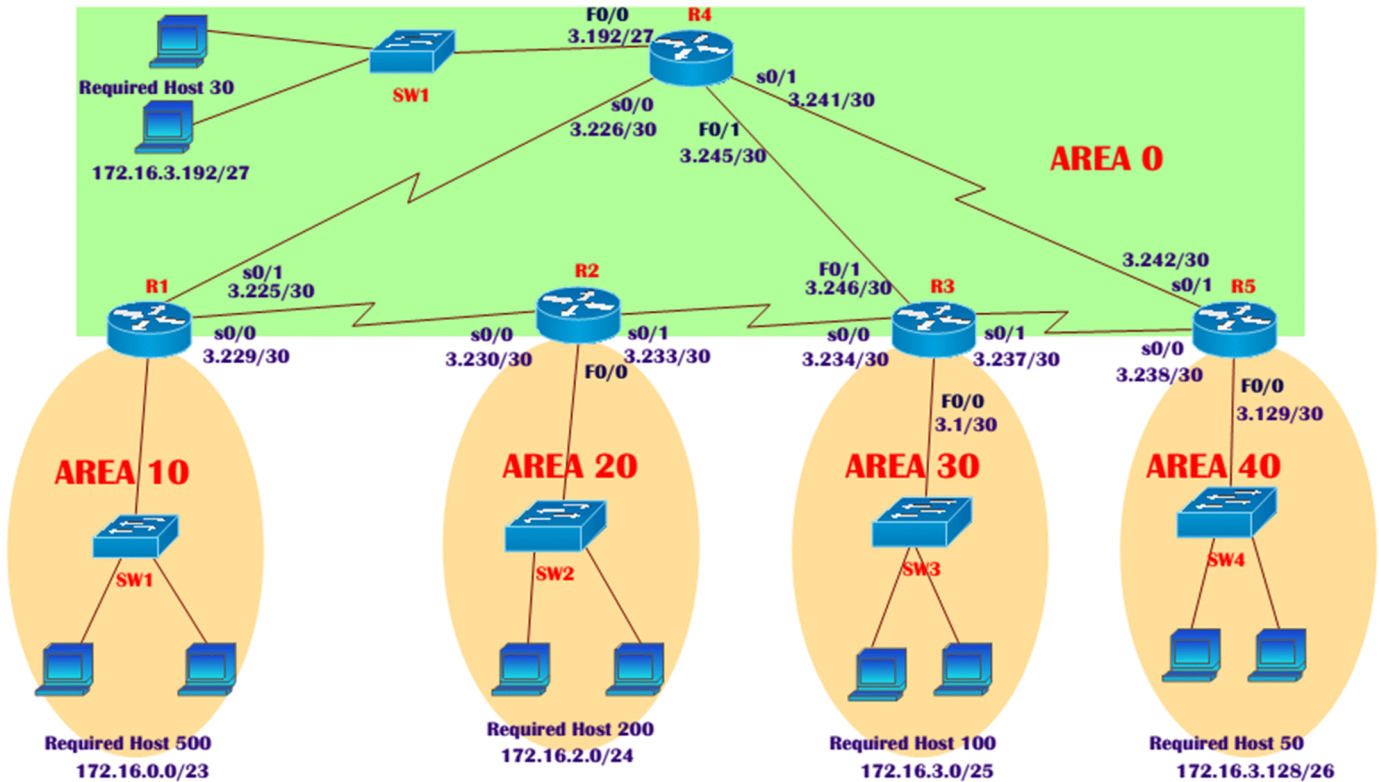
Serial0/0 is up, line protocol is up (connected)  
Hardware is HD64570  
Internet address is 172.16.3.226/30  
MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,  
reliability 255/255, txload 1/255, rxload 1/255  
Encapsulation PPP, loopback not set, keepalive set (10 sec)  
LCP Open  
Open: IPCP, CDPCP  
Last input never, output never, output hang never  
Last clearing of "show interface" counters never  
Input queue: 0/75/0 (size/max/drops); Total output drops: 0  
Queueing strategy: weighted fair  
Output queue: 0/1000/64/0 (size/max total/threshold/drops)  
Conversations 0/0/256 (active/max active/max total)  
Reserved Conversations 0/0 (allocated/max allocated)  
Available Bandwidth 1158 kilobits/sec  
5 minute input rate 0 bits/sec, 0 packets/sec  
5 minute output rate 1 bits/sec, 0 packets/sec  
1191 packets input, 71815 bytes, 0 no buffer  
Received 2 broadcasts, 0 runts, 0 giants, 0 throttles  
0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort  
1219 packets output, 72588 bytes, 0 underruns  
0 output errors, 0 collisions, 1 interface resets  
0 output buffer failures, 0 output buffers swapped out  
0 carrier transitions  
DCD=up DSR=up DTR=up RTS=up CTS=up

R-4#





**TASK: Configure OSPF using multiple areas as per the diagram**



```
R-4(config)#router ospf 1
R-4(config-router)#network 172.16.3.192 0.0.0.31 area 0
R-4(config-router)#network 172.16.3.224 0.0.0.3 area 0
R-4(config-router)#network 172.16.3.244 0.0.0.3 area 0
R-4(config-router)#network 172.16.3.240 0.0.0.3 area 0
R-4(config-router)#exit
```

```
R-1(config)# router ospf 1
R-1(config-router)# network 172.16.0.0 0.0.1.255 area 10
R-1(config-router)# network 172.16.3.224 0.0.0.3 area 0
R-1(config-router)# network 172.16.3.228 0.0.0.3 area 0
R-1(config-router)#exit
```

```
R-2(config)#router ospf 1
R-2(config-router)#network 172.16.2.0 0.0.0.255 area 20
R-2(config-router)#network 172.16.3.228 0.0.0.3 area 0
R-2(config-router)#network 172.16.3.232 0.0.0.3 area 0
R-2(config-router)#exit
```

```
R-2#sh ip ospf neighbor
Neighbor ID Pri State Dead Time Address Interface
172.16.3.229 0 FULL/ - 00:00:35 172.16.3.229 Serial0/0
```

```
R-3(config)#router ospf 1
R-3(config-router)#network 172.16.3.0 0.0.0.127 area 30
R-3(config-router)#network 172.16.3.232 0.0.0.3 area 0
```

```
R-3(config-router)#network 172.16.3.236 0.0.0.3 area 0
R-3(config-router)#network 172.16.3.244 0.0.0.3 area 0
R-3(config-router)#exit
```

```
R-5(config)#router ospf 1
R-5(config-router)#network 172.16.3.128 0.0.0.63 area 50
R-5(config-router)#network 172.16.3.236 0.0.0.3 area 0
R-5(config-router)#network 172.16.3.236 0.0.0.3 area 0
R-5(config-router)#network 172.16.3.240 0.0.0.3 area 0
R-5(config-router)#end
```

R-5#sh ip ospf neighbor

| Neighbor ID  | Pri | State   | Dead Time | Address      | Interface |
|--------------|-----|---------|-----------|--------------|-----------|
| 172.16.3.246 | 0   | FULL/ - | 00:00:35  | 172.16.3.237 | Serial0/0 |
| 172.16.3.245 | 0   | FULL/ - | 00:00:38  | 172.16.3.241 | Serial0/1 |

R-5#sh ip route ospf

172.16.0.0/16 is variably subnetted, 11 subnets, 6 masks

- IA 172.16.0.0 [110/129] via 172.16.3.241, 00:00:30, Serial0/1
- IA 172.16.2.0 [110/129] via 172.16.3.237, 00:00:40, Serial0/0
- IA 172.16.3.0 [110/65] via 172.16.3.237, 00:00:40, Serial0/0
- 172.16.3.192 [110/65] via 172.16.3.241, 00:00:30, Serial0/1
- 172.16.3.224 [110/128] via 172.16.3.241, 00:00:30, Serial0/1
- 172.16.3.228 [110/192] via 172.16.3.237, 00:00:30, Serial0/0
- [110/192] via 172.16.3.241, 00:00:30, Serial0/1
- 172.16.3.232 [110/128] via 172.16.3.237, 00:00:40, Serial0/0
- 172.16.3.244 [110/65] via 172.16.3.237, 00:00:30, Serial0/0
- [110/65] via 172.16.3.241, 00:00:30, Serial0/1

R-5#sh ip ospf database

OSPF Router with ID (172.16.3.242) (Process ID 1)

Router Link States (Area 0)

| Link ID      | ADV Router   | Age | Seq#       | Checksum | Link count |
|--------------|--------------|-----|------------|----------|------------|
| 172.16.3.229 | 172.16.3.229 | 294 | 0x80000004 | 0x0042b0 | 4          |
| 172.16.3.233 | 172.16.3.233 | 205 | 0x80000004 | 0x000dcf | 4          |
| 172.16.3.246 | 172.16.3.246 | 68  | 0x80000006 | 0x00b182 | 5          |
| 172.16.3.242 | 172.16.3.242 | 55  | 0x80000004 | 0x00eeaa | 4          |
| 172.16.3.245 | 172.16.3.245 | 55  | 0x80000008 | 0x00f7d7 | 6          |

Net Link States (Area 0)

| Link ID      | ADV Router   | Age | Seq#       | Checksum |
|--------------|--------------|-----|------------|----------|
| 172.16.3.245 | 172.16.3.245 | 170 | 0x80000001 | 0x00338f |

Summary Net Link States (Area 0)

| Link ID      | ADV Router   | Age | Seq#       | Checksum |
|--------------|--------------|-----|------------|----------|
| 172.16.2.0   | 172.16.3.233 | 379 | 0x80000001 | 0x00d520 |
| 172.16.0.0   | 172.16.3.229 | 460 | 0x80000001 | 0x00fefb |
| 172.16.3.0   | 172.16.3.246 | 201 | 0x80000001 | 0x007ee8 |
| 172.16.3.128 | 172.16.3.242 | 68  | 0x80000001 | 0x001397 |

## Router Link States (Area 50)

| Link ID      | ADV Router   | Age | Seq#       | Checksum | Link count |
|--------------|--------------|-----|------------|----------|------------|
| 172.16.3.242 | 172.16.3.242 | 72  | 0x80000002 | 0x006289 | 1          |

## Summary Net Link States (Area 50)

| Link ID      | ADV Router   | Age | Seq#       | Checksum |
|--------------|--------------|-----|------------|----------|
| 172.16.3.244 | 172.16.3.242 | 58  | 0x80000001 | 0x007247 |
| 172.16.3.236 | 172.16.3.242 | 58  | 0x80000002 | 0x00b60b |
| 172.16.3.240 | 172.16.3.242 | 58  | 0x80000003 | 0x008c30 |
| 172.16.3.232 | 172.16.3.242 | 58  | 0x80000004 | 0x005d26 |
| 172.16.3.228 | 172.16.3.242 | 58  | 0x80000007 | 0x000242 |
| 172.16.2.0   | 172.16.3.242 | 58  | 0x80000008 | 0x0095cf |
| 172.16.3.0   | 172.16.3.242 | 58  | 0x8000000a | 0x00071b |
| 172.16.3.192 | 172.16.3.242 | 48  | 0x8000000b | 0x00c03f |
| 172.16.3.224 | 172.16.3.242 | 48  | 0x8000000c | 0x009de5 |
| 172.16.0.0   | 172.16.3.242 | 48  | 0x8000000d | 0x009cc6 |

### R-4#sh ip route ospf

172.16.0.0/16 is variably subnetted, 12 subnets, 7 masks

- IA 172.16.0.0 [110/65] via 172.16.3.225, 00:08:40, Serial0/0
- IA 172.16.2.0 [110/66] via 172.16.3.246, 00:03:50, FastEthernet0/1
- IA 172.16.3.0 [110/2] via 172.16.3.246, 00:03:50, FastEthernet0/1
- IA 172.16.3.128 [110/65] via 172.16.3.242, 00:01:53, Serial0/1
- 172.16.3.228 [110/128] via 172.16.3.225, 00:05:52, Serial0/0
- 172.16.3.232 [110/65] via 172.16.3.246, 00:03:50, FastEthernet0/1
- 172.16.3.236 [110/65] via 172.16.3.246, 00:03:50, FastEthernet0/1

### R-1#sh ip route ospf

172.16.0.0/16 is variably subnetted, 13 subnets, 7 masks

- IA 172.16.2.0 [110/65] via 172.16.3.230, 00:08:04, Serial0/0
- IA 172.16.3.0 [110/66] via 172.16.3.226, 00:06:02, Serial0/1
- IA 172.16.3.128 [110/129] via 172.16.3.226, 00:04:05, Serial0/1
- 172.16.3.192 [110/65] via 172.16.3.226, 00:10:53, Serial0/1
- 172.16.3.232 [110/128] via 172.16.3.230, 00:08:04, Serial0/0
- 172.16.3.236 [110/129] via 172.16.3.226, 00:06:02, Serial0/1
- 172.16.3.240 [110/128] via 172.16.3.226, 00:10:53, Serial0/1
- 172.16.3.244 [110/65] via 172.16.3.226, 00:10:53, Serial0/1

### R-1#traceroute 172.16.3.193

Type escape sequence to abort.

Tracing the route to 172.16.3.193

1 172.16.3.226 5 msec 2 msec 8 msec

### R-1#traceroute 172.16.3.129

Type escape sequence to abort.

Tracing the route to 172.16.3.129

1 172.16.3.226 6 msec 7 msec 2 msec



2 172.16.3.242 0 msec 0 msec 4 msec

**TASK: Change the router-ID of all routers to x.x.x.x**

R-1(config)#router ospf 1

R-1(config-router)#router-id 1.1.1.1

Reload or use "clear ip ospf process" command, for this to take effect

R-1(config-router)#end

R-1#clear ip ospf process

Reset ALL OSPF processes? [no]: yes

R-1#sh ip protocols

Routing Protocol is "ospf 1"

Outgoing update filter list for all interfaces is not set

Incoming update filter list for all interfaces is not set

Router ID 1.1.1.1

Number of areas in this router is 3. 3 normal 0 stub 0 nssa

Maximum path: 4

Routing for Networks:

172.16.0.0 0.0.1.255 area 10

172.16.3.224 0.0.0.3 area 0

172.16.3.228 0.0.0.3 area 0

Routing Information Sources:

| Gateway | Distance | Last Update |
|---------|----------|-------------|
|---------|----------|-------------|

|         |     |          |
|---------|-----|----------|
| 1.1.1.1 | 110 | 00:00:14 |
|---------|-----|----------|

|              |     |          |
|--------------|-----|----------|
| 172.16.3.229 | 110 | 00:10:26 |
|--------------|-----|----------|

|              |     |          |
|--------------|-----|----------|
| 172.16.3.233 | 110 | 00:00:17 |
|--------------|-----|----------|

|              |     |          |
|--------------|-----|----------|
| 172.16.3.242 | 110 | 00:06:27 |
|--------------|-----|----------|

|              |     |          |
|--------------|-----|----------|
| 172.16.3.245 | 110 | 00:00:14 |
|--------------|-----|----------|

|              |     |          |
|--------------|-----|----------|
| 172.16.3.246 | 110 | 00:06:40 |
|--------------|-----|----------|

Distance: (default is 110)

R-2#sh ip protocols

Routing Protocol is "ospf 1"

Outgoing update filter list for all interfaces is not set

Incoming update filter list for all interfaces is not set

Router ID 172.16.3.233

Number of areas in this router is 2. 2 normal 0 stub 0 nssa

Maximum path: 4

Routing for Networks:

172.16.2.0 0.0.0.255 area 20

172.16.3.228 0.0.0.3 area 0

172.16.3.232 0.0.0.3 area 0

Routing Information Sources:

| Gateway | Distance | Last Update |
|---------|----------|-------------|
|---------|----------|-------------|

|         |     |          |
|---------|-----|----------|
| 1.1.1.1 | 110 | 00:00:27 |
|---------|-----|----------|

|              |     |          |
|--------------|-----|----------|
| 172.16.3.229 | 110 | 00:10:38 |
|--------------|-----|----------|

|              |     |          |
|--------------|-----|----------|
| 172.16.3.233 | 110 | 00:00:29 |
|--------------|-----|----------|

|              |     |          |
|--------------|-----|----------|
| 172.16.3.242 | 110 | 00:06:39 |
|--------------|-----|----------|

|              |     |          |
|--------------|-----|----------|
| 172.16.3.245 | 110 | 00:00:27 |
|--------------|-----|----------|

172.16.3.246 110 00:06:52  
Distance: (default is 110)

```
R-2(config)#router ospf 1
R-2(config-router)#router-id 2.2.2.2
R-2(config-router)#end
```

```
R-2#clear ip ospf process
Reset ALL OSPF processes? [no]: yes
```

```
R-2#sh ip protocols
Routing Protocol is "ospf 1"
 Outgoing update filter list for all interfaces is not set
 Incoming update filter list for all interfaces is not set
 Router ID 2.2.2.2
 Number of areas in this router is 2. 2 normal 0 stub 0 nssa
 Maximum path: 4
 Routing for Networks:
 172.16.2.0 0.0.0.255 area 20
 172.16.3.228 0.0.0.3 area 0
 172.16.3.232 0.0.0.3 area 0
 Routing Information Sources:
 Gateway Distance Last Update
 1.1.1.1 110 00:00:27
 172.16.3.229 110 00:10:38
 172.16.3.233 110 00:00:29
 172.16.3.242 110 00:06:39
 172.16.3.245 110 00:00:27
 172.16.3.246 110 00:06:52
 Distance: (default is 110)
```

```
R-3(config)#router ospf 1
R-3(config-router)#router-id 3.3.3.3
R-3(config-router)#end
```

```
R-3#clear ip ospf process
Reset ALL OSPF processes? [no]: yes
```

```
R-5(config)#router ospf 1
R-5(config-router)#router-id 5.5.5.5
R-5(config-router)#end
```

```
R-5#clear ip ospf process
Reset ALL OSPF processes? [no]: yes
```

```
R-4(config)#router ospf 1
R-4(config-router)#router-id 4.4.4.4
R-4(config-router)#end
```

```
R-4#clear ip ospf process
```

Reset ALL OSPF processes? [no]: yes

R-4#sh ip protocols

Routing Protocol is "ospf 1"

Outgoing update filter list for all interfaces is not set

Incoming update filter list for all interfaces is not set

Router ID 4.4.4.4

Number of areas in this router is 1. 1 normal 0 stub 0 nssa

Maximum path: 4

Routing for Networks:

172.16.3.192 0.0.0.31 area 0

172.16.3.224 0.0.0.3 area 0

172.16.3.244 0.0.0.3 area 0

172.16.3.240 0.0.0.3 area 0

Routing Information Sources:

| Gateway | Distance | Last Update |
|---------|----------|-------------|
|---------|----------|-------------|

|         |     |          |
|---------|-----|----------|
| 1.1.1.1 | 110 | 00:00:07 |
|---------|-----|----------|

|         |     |          |
|---------|-----|----------|
| 3.3.3.3 | 110 | 00:00:01 |
|---------|-----|----------|

|         |     |          |
|---------|-----|----------|
| 4.4.4.4 | 110 | 00:00:01 |
|---------|-----|----------|

|         |     |          |
|---------|-----|----------|
| 5.5.5.5 | 110 | 00:00:05 |
|---------|-----|----------|

|              |     |          |
|--------------|-----|----------|
| 172.16.3.229 | 110 | 00:13:14 |
|--------------|-----|----------|

|              |     |          |
|--------------|-----|----------|
| 172.16.3.233 | 110 | 00:01:36 |
|--------------|-----|----------|

|              |     |          |
|--------------|-----|----------|
| 172.16.3.242 | 110 | 00:01:31 |
|--------------|-----|----------|

|              |     |          |
|--------------|-----|----------|
| 172.16.3.245 | 110 | 00:00:27 |
|--------------|-----|----------|

|              |     |          |
|--------------|-----|----------|
| 172.16.3.246 | 110 | 00:09:28 |
|--------------|-----|----------|

Distance: (default is 110)

**TASK:** Shutdown the link between R1- R4 to check alternate route R1 uses to reach R5

R-1(config)#int s0/1

R-1(config-if)#shutdown

R-1(config)#exit

R-1(config)#int s0/1

R-1(config-if)#shutdown

R-1(config-if)#end

R-1#sh ip route ospf

172.16.0.0/16 is variably subnetted, 10 subnets, 6 masks

○ IA 172.16.2.0 [110/65] via 172.16.3.230, 00:01:05, Serial0/0

○ IA 172.16.3.128 [110/193] via 172.16.3.230, 00:00:07, Serial0/0

○ 172.16.3.192 [110/130] via 172.16.3.230, 00:00:07, Serial0/0

○ 172.16.3.232 [110/128] via 172.16.3.230, 00:01:05, Serial0/0

○ 172.16.3.236 [110/192] via 172.16.3.230, 00:00:07, Serial0/0

○ 172.16.3.240 [110/193] via 172.16.3.230, 00:00:07, Serial0/0

○ 172.16.3.244 [110/129] via 172.16.3.230, 00:00:07, Serial0/0

R-1#traceroute 172.16.3.129

Type escape sequence to abort.

Tracing the route to 172.16.3.129



|   |              |        |         |         |
|---|--------------|--------|---------|---------|
| 1 | 172.16.3.230 | 1 msec | 1 msec  | 17 msec |
| 2 | 172.16.3.234 | 0 msec | 10 msec | 0 msec  |
| 3 | 172.16.3.238 | 6 msec | 3 msec  | 3 msec  |

R-1(config)#int s0/1

R-1(config-if)#no shutdown

R-1(config-if)#exit

R-1#sh ip route ospf

172.16.0.0/16 is variably subnetted, 12 subnets, 6 masks

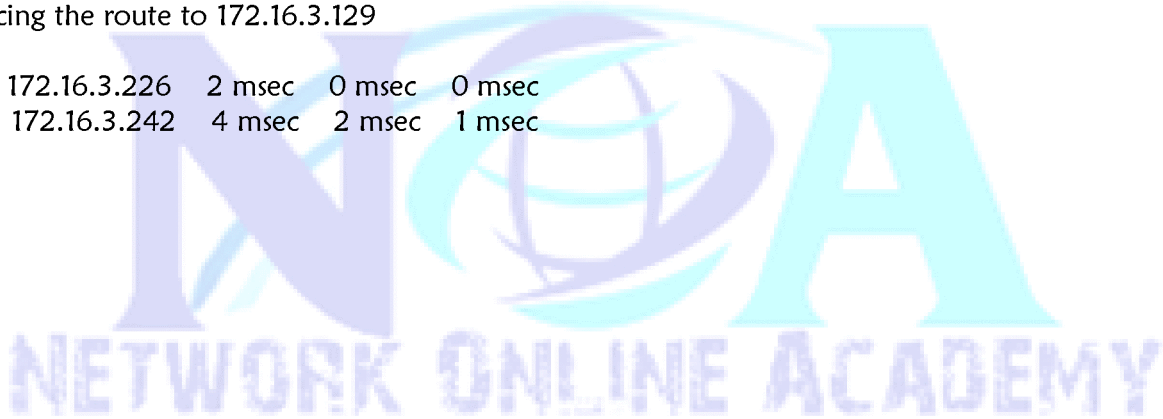
- IA 172.16.2.0 [110/65] via 172.16.3.230, 00:02:07, Serial0/0
- IA 172.16.3.128 [110/129] via 172.16.3.226, 00:00:05, Serial0/1
- 172.16.3.192 [110/65] via 172.16.3.226, 00:00:05, Serial0/1
- 172.16.3.232 [110/128] via 172.16.3.230, 00:02:07, Serial0/0
- 172.16.3.236 [110/129] via 172.16.3.226, 00:00:05, Serial0/1
- 172.16.3.240 [110/128] via 172.16.3.226, 00:00:05, Serial0/1
- 172.16.3.244 [110/65] via 172.16.3.226, 00:00:05, Serial0/1

R-1#traceroute 172.16.3.129

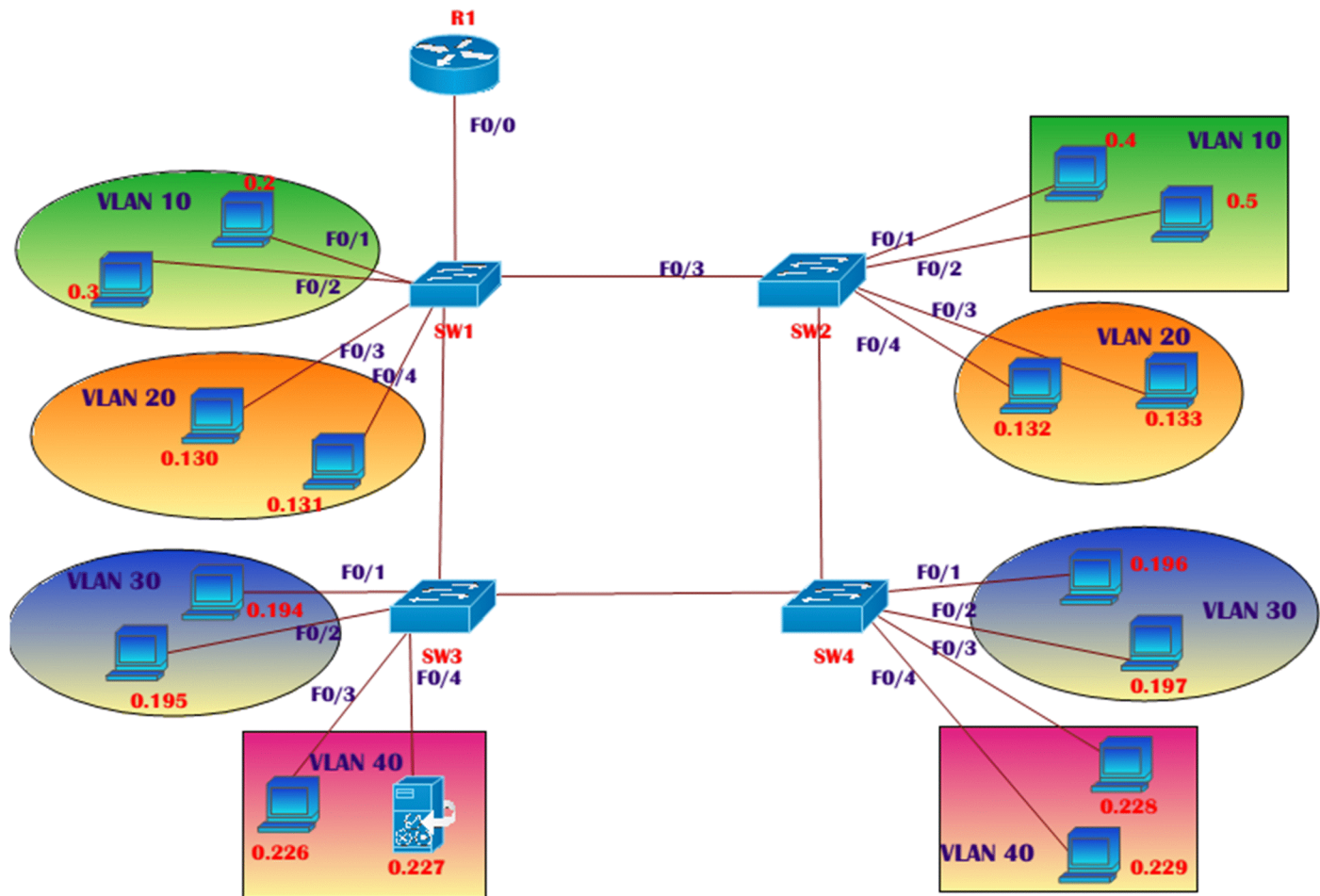
Type escape sequence to abort.

Tracing the route to 172.16.3.129

|   |              |        |        |        |
|---|--------------|--------|--------|--------|
| 1 | 172.16.3.226 | 2 msec | 0 msec | 0 msec |
| 2 | 172.16.3.242 | 4 msec | 2 msec | 1 msec |



## SWITCHING MOCK LAB:



### TASK:

- Continue with same Topology and add switches in the R1 LAN as per the diagram
  - Use VLSM and Assign IP addresses for the hosts using subnet 172.16.0.0/23
  - Write the range of the IP addresses to be assigned to each vlan
- Vlan 10 (yellow) required hosts: 120 hosts
  - Vlan 20 (green) required hosts: 60 hosts
  - Vlan 30 (Blue) required hosts: 30 hosts
  - Vlan 30 (Red) required hosts: 12 hosts

### Solution:

Range as per the Requirement:

- |                                               |                                   |
|-----------------------------------------------|-----------------------------------|
| • Vlan 10 (yellow) required hosts : 120 hosts | 172.16.0.0/25 - 172.16.0.127/25   |
| • Vlan 20 (green) required hosts : 60 hosts   | 172.16.0.128/26 - 172.16.0.191/26 |
| • Vlan 30 (Blue) required hosts : 30 hosts    | 172.16.0.192/27 - 172.16.0.223/27 |
| • Vlan 30 (Red) required hosts : 12 hosts     | 172.16.0.224/28 - 172.16.0.239/28 |

### TASK:

- Assign the IP address to the hosts with their own respective gateway IP addresses:
- First IP address of the range to be assigned to default gateway.

Create Vlan on all switches.

vlan 10 = yellow  
 vlan 20 = Green  
 vlan 30 = Blue  
 vlan 40 = Red

- Assign port in to their respective ports on each switch

on SWA/SwB/SWC/SWD

```
SW-D(config)#vlan 10
SW-D(config-vlan)# name yellow
SW-D(config-vlan)# vlan 20
SW-D(config-vlan)# name Green
SW-D(config-vlan)# vlan 30
SW-D(config-vlan)# name Blue
SW-D(config-vlan)# vlan 40
SW-D(config-vlan)# name Red
SW-D(config-vlan)#end
```

SW-D#sh vlan

| VLAN Name | Status | Ports                                                                                                                                                                                                             |
|-----------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 default | active | Fa0/1, Fa0/2, Fa0/3, Fa0/4<br>Fa0/5, Fa0/6, Fa0/7, Fa0/8<br>Fa0/9, Fa0/10, Fa0/11, Fa0/12<br>Fa0/13, Fa0/14, Fa0/15, Fa0/16<br>Fa0/17, Fa0/18, Fa0/19, Fa0/20<br>Fa0/21, Fa0/22, Fa0/23, Fa0/24<br>Gig1/1, Gig1/2 |
| 10 yellow | active |                                                                                                                                                                                                                   |
| 20 Green  | active |                                                                                                                                                                                                                   |
| 30 Blue   | active |                                                                                                                                                                                                                   |
| 40 Red    | active |                                                                                                                                                                                                                   |

```
SW-A(config)#int range f0/1- 2
SW-A(config-if-range)#switchport mode access
SW-A(config-if-range)#switchport access vlan 10
SW-A(config-if-range)#exit
```

```
SW-A(config)#interface range f0/3 - 4
SW-A(config-if-range)#switchport mode access
SW-A(config-if-range)#switchport access vlan 20
SW-A(config-if-range)#exit
```

SW-A#sh vlan

Status Ports



```

1 default active Fa0/5, Fa0/6, Fa0/7, Fa0/8
Fa0/9, Fa0/10, Fa0/11, Fa0/12
Fa0/13, Fa0/14, Fa0/15, Fa0/16
Fa0/17, Fa0/18, Fa0/19, Fa0/20
Fa0/21, Fa0/22, Fa0/23, Fa0/24
Gig1/1, Gig1/2
10 yellow active Fa0/1, Fa0/2
20 Green active Fa0/3, Fa0/4
30 Blue active
40 Red active
1002 fddi-default act/unsup
1003 token-ring-default act/unsup
1004 fddinet-default act/unsup

```

```

SW-B(config)#interface range f0/1 - 2
SW-B(config-if-range)#switchport mode access
SW-B(config-if-range)#switchport access vlan 10
SW-B(config-if-range)#exit

```

```

SW-B(config)#interface range f0/3 - 4
SW-B(config-if-range)#switchport mode access
SW-B(config-if-range)#switchport access vlan 20
SW-B(config-if-range)#end

```

```

SW-B#sh vlan
VLAN Name Status Ports

1 default active Fa0/5, Fa0/6, Fa0/7, Fa0/8
Fa0/9, Fa0/10, Fa0/11, Fa0/12
Fa0/13, Fa0/14, Fa0/15, Fa0/16
Fa0/17, Fa0/18, Fa0/19, Fa0/20
Fa0/21, Fa0/22, Fa0/23, Fa0/24
Gig1/1, Gig1/2
10 yellow active Fa0/1, Fa0/2
20 Green active Fa0/3, Fa0/4
30 Blue active
40 Red active
1002 fddi-default act/unsup
1003 token-ring-default act/unsup
1004 fddinet-default act/unsup
1005 trnet-default act/unsup

```

```

PC>ipconfig
FastEthernet0 Connection:(default port)
Link-local IPv6 Address.....: FE80::203:E4FF:FE9B:E9AE
IP Address.....: 172.16.0.2
Subnet Mask.....: 255.255.255.128
Default Gateway.....: 172.16.0.1

```

```

PC>ping 172.16.0.3

```

Pinging 172.16.0.3 with 32 bytes of data:  
Reply from 172.16.0.3: bytes=32 time=1ms TTL=128  
Reply from 172.16.0.3: bytes=32 time=0ms TTL=128  
Reply from 172.16.0.3: bytes=32 time=0ms TTL=128  
Reply from 172.16.0.3: bytes=32 time=0ms TTL=128

PC>ping 172.16.0.4  
Pinging 172.16.0.4 with 32 bytes of data:  
Request timed out.  
Request timed out.  
Request timed out.  
Request timed out.

NOTE:

*You can ping to same vlan users on the same switch but not on the other end of switch as we did not configured trunking still.*

PC>ipconfig  
FastEthernet0 Connection:(default port)  
Link-local IPv6 Address.....: FE80::20A:41FF:FE6A:D14A  
IP Address.....: 172.16.0.130  
Subnet Mask.....: 255.255.255.192  
Default Gateway.....: 172.16.0.129

PC>ping 172.16.0.131  
Pinging 172.16.0.131 with 32 bytes of data:  
  
Reply from 172.16.0.131: bytes=32 time=0ms TTL=128  
Reply from 172.16.0.131: bytes=32 time=0ms TTL=128  
Reply from 172.16.0.131: bytes=32 time=0ms TTL=128  
Reply from 172.16.0.131: bytes=32 time=1ms TTL=128

PC>ping 172.16.0.132  
Pinging 172.16.0.132 with 32 bytes of data:  
  
Request timed out.  
Request timed out.  
Request timed out.  
Request timed out.

SW-C(config)#interface range f0/1 - 2  
SW-C(config-if-range)#switchport mode access  
SW-C(config-if-range)#switchport access vlan 30  
SW-C(config-if-range)#exit

SW-C(config)#interface range f0/3 - 4  
SW-C(config-if-range)#switchport mode access  
SW-C(config-if-range)#switchport access vlan 40  
SW-C(config-if-range)#exit

SW-C#sh vlan

| VLAN Name               | Status    | Ports                                                                                                                                                                               |
|-------------------------|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 default               | active    | Fa0/5, Fa0/6, Fa0/7, Fa0/8<br>Fa0/9, Fa0/10, Fa0/11, Fa0/12<br>Fa0/13, Fa0/14, Fa0/15, Fa0/16<br>Fa0/17, Fa0/18, Fa0/19, Fa0/20<br>Fa0/21, Fa0/22, Fa0/23, Fa0/24<br>Gig1/1, Gig1/2 |
| 10 yellow               | active    |                                                                                                                                                                                     |
| 20 Green                | active    |                                                                                                                                                                                     |
| 30 Blue                 | active    | Fa0/1, Fa0/2                                                                                                                                                                        |
| 40 Red                  | active    | Fa0/3, Fa0/4                                                                                                                                                                        |
| 1002 fddi-default       | act/unsup |                                                                                                                                                                                     |
| 1003 token-ring-default | act/unsup |                                                                                                                                                                                     |

```
SW-D(config)#interface range f0/1- 2
SW-D(config-if-range)#switchport mode access
SW-D(config-if-range)#switchport access vlan 30
SW-D(config-if-range)#exit
```

```
SW-D(config)#interface range f0/3 - 4
SW-D(config-if-range)#switchport mode access
SW-D(config-if-range)#switchport access vlan 40
SW-D(config-if-range)#exit
```

SW-D#sh vlan

| VLAN Name               | Status    | Ports                                                                                                                                                                               |
|-------------------------|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 default               | active    | Fa0/5, Fa0/6, Fa0/7, Fa0/8<br>Fa0/9, Fa0/10, Fa0/11, Fa0/12<br>Fa0/13, Fa0/14, Fa0/15, Fa0/16<br>Fa0/17, Fa0/18, Fa0/19, Fa0/20<br>Fa0/21, Fa0/22, Fa0/23, Fa0/24<br>Gig1/1, Gig1/2 |
| 10 yellow               | active    |                                                                                                                                                                                     |
| 20 Green                | active    |                                                                                                                                                                                     |
| 30 Blue                 | active    | Fa0/1, Fa0/2                                                                                                                                                                        |
| 40 Red                  | active    | Fa0/3, Fa0/4                                                                                                                                                                        |
| 1002 fddi-default       | act/unsup |                                                                                                                                                                                     |
| 1003 token-ring-default | act/unsup |                                                                                                                                                                                     |
| 1004 fddinet-default    | act/unsup |                                                                                                                                                                                     |
| 1005 trnet-default      | act/unsup |                                                                                                                                                                                     |

```
PC>ipconfig
FastEthernet0 Connection:(default port)
Link-local IPv6 Address.....: FE80::201:C9FF:FE8A:B64D
IP Address.....: 172.16.0.194
Subnet Mask.....: 255.255.255.224
Default Gateway.....: 172.16.0.193
```

```
PC>ping 172.16.0.195
```



Pinging 172.16.0.195 with 32 bytes of data:  
Reply from 172.16.0.195: bytes=32 time=4ms TTL=128  
Reply from 172.16.0.195: bytes=32 time=0ms TTL=128  
Reply from 172.16.0.195: bytes=32 time=0ms TTL=128  
Reply from 172.16.0.195: bytes=32 time=0ms TTL=128

PC>ping 172.16.0.196

Pinging 172.16.0.196 with 32 bytes of data:  
Request timed out.  
Request timed out.  
Request timed out.  
Request timed out.

PC>ipconfig

FastEthernet0 Connection:(default port)  
Link-local IPv6 Address.....: FE80::203:E4FF:FE56:D8BB  
IP Address.....: 172.16.0.226  
Subnet Mask.....: 255.255.255.240  
Default Gateway.....: 172.16.0.225

PC>ping 172.16.0.227

Pinging 172.16.0.227 with 32 bytes of data:  
  
Reply from 172.16.0.227: bytes=32 time=1ms TTL=128  
Reply from 172.16.0.227: bytes=32 time=0ms TTL=128  
Reply from 172.16.0.227: bytes=32 time=0ms TTL=128  
Reply from 172.16.0.227: bytes=32 time=0ms TTL=128

PC>ping 172.16.0.228

Pinging 172.16.0.228 with 32 bytes of data:  
  
Request timed out.  
Request timed out.  
Request timed out.  
Request timed out.

#### TASK:

- **Configure the links connecting between switches as trunk links to ensure that users of same vlan on different switches can ping each other.**

SW-A(config)#interface range f0/21, f0/24  
SW-A(config-if-range)#switchport mode trunk  
SW-A(config-if-range)#exit

SW-B(config)#interface range f0/21 , f0/22  
SW-B(config-if-range)#switchport mode trunk  
SW-B(config-if-range)#end

SW-C(config)#interface range f0/23 - 24  
SW-C(config-if-range)#switchport mode trunk  
SW-C(config-if-range)#end

```
SW-D(config)#interface range f0/22 , f0/23
SW-D(config-if-range)#switchport mode trunk
SW-D(config-if-range)#end
```

SW-D#sh interfaces trunk

| Port   | Mode | Encapsulation | Status   | Native vlan |
|--------|------|---------------|----------|-------------|
| Fa0/22 | on   | 802.1q        | trunking | 1           |
| Fa0/23 | on   | 802.1q        | trunking | 1           |

| Port   | Vlans allowed on trunk |
|--------|------------------------|
| Fa0/22 | 1-1005                 |
| Fa0/23 | 1-1005                 |

| Port   | Vlans allowed and active in management domain |
|--------|-----------------------------------------------|
| Fa0/22 | 1,10,20,30,40                                 |
| Fa0/23 | 1,10,20,30,40                                 |

| Port   | Vlans in spanning tree forwarding state and not pruned |
|--------|--------------------------------------------------------|
| Fa0/22 | 1,10,20,30,40                                          |
| Fa0/23 | 1,10,20,30,40                                          |

SW-A#sh interfaces trunk

| Port   | Mode | Encapsulation | Status   | Native vlan |
|--------|------|---------------|----------|-------------|
| Fa0/21 | on   | 802.1q        | trunking | 1           |
| Fa0/24 | on   | 802.1q        | trunking | 1           |

| Port   | Vlans allowed on trunk |
|--------|------------------------|
| Fa0/21 | 1-1005                 |
| Fa0/24 | 1-1005                 |

| Port   | Vlans allowed and active in management domain |
|--------|-----------------------------------------------|
| Fa0/21 | 1,10,20,30,40                                 |
| Fa0/24 | 1,10,20,30,40                                 |

| Port   | Vlans in spanning tree forwarding state and not pruned |
|--------|--------------------------------------------------------|
| Fa0/21 | 1,10,20,30,40                                          |
| Fa0/24 | 1,10,20,30,40                                          |

PC>ipconfig

```
FastEthernet0 Connection:(default port)
Link-local IPv6 Address.....: FE80::203:E4FF:FE9B:E9AE
IP Address.....: 172.16.0.2
Subnet Mask.....: 255.255.255.128
Default Gateway.....: 172.16.0.1
```

PC>ping 172.16.0.4

Pinging 172.16.0.4 with 32 bytes of data:

```
Reply from 172.16.0.4: bytes=32 time=0ms TTL=128
Reply from 172.16.0.4: bytes=32 time=0ms TTL=128
```

Reply from 172.16.0.4: bytes=32 time=1ms TTL=128

Reply from 172.16.0.4: bytes=32 time=0ms TTL=128

PC>ping 172.16.0.5

Pinging 172.16.0.5 with 32 bytes of data:

Reply from 172.16.0.5: bytes=32 time=0ms TTL=128

Reply from 172.16.0.5: bytes=32 time=0ms TTL=128

Reply from 172.16.0.5: bytes=32 time=0ms TTL=128

Reply from 172.16.0.5: bytes=32 time=0ms TTL=128

PC>ipconfig

FastEthernet0 Connection:(default port)

Link-local IPv6 Address.....: FE80::20A:41FF:FE6A:D14A

IP Address.....: 172.16.0.130

Subnet Mask.....: 255.255.255.192

Default Gateway.....: 172.16.0.129

PC>ping 172.16.0.132

Pinging 172.16.0.132 with 32 bytes of data:

Reply from 172.16.0.132: bytes=32 time=0ms TTL=128

Reply from 172.16.0.132: bytes=32 time=0ms TTL=128

Reply from 172.16.0.132: bytes=32 time=0ms TTL=128

Reply from 172.16.0.132: bytes=32 time=0ms TTL=128

PC>ping 172.16.0.133

Pinging 172.16.0.133 with 32 bytes of data:

Reply from 172.16.0.133: bytes=32 time=1ms TTL=128

Reply from 172.16.0.133: bytes=32 time=0ms TTL=128

Reply from 172.16.0.133: bytes=32 time=10ms TTL=128

Reply from 172.16.0.133: bytes=32 time=0ms TTL=128

PC>ipconfig

FastEthernet0 Connection:(default port)

Link-local IPv6 Address.....: FE80::201:C9FF:FE8A:B64D

IP Address.....: 172.16.0.194

Subnet Mask.....: 255.255.255.224

Default Gateway.....: 172.16.0.193

PC>ping 172.16.0.196

Pinging 172.16.0.196 with 32 bytes of data:

Reply from 172.16.0.196: bytes=32 time=0ms TTL=128

Reply from 172.16.0.196: bytes=32 time=1ms TTL=128

Reply from 172.16.0.196: bytes=32 time=0ms TTL=128

Reply from 172.16.0.196: bytes=32 time=0ms TTL=128

PC>ping 172.16.0.197

Pinging 172.16.0.197 with 32 bytes of data:



Reply from 172.16.0.197: bytes=32 time=24ms TTL=128  
 Reply from 172.16.0.197: bytes=32 time=0ms TTL=128  
 Reply from 172.16.0.197: bytes=32 time=1ms TTL=128  
 Reply from 172.16.0.197: bytes=32 time=0ms TTL=128

PC>ipconfig

FastEthernet0 Connection:(default port)  
 Link-local IPv6 Address.....: FE80::203:E4FF:FE56:D8BB  
 IP Address.....: 172.16.0.226  
 Subnet Mask.....: 255.255.255.240  
 Default Gateway.....: 172.16.0.225

PC>ping 172.16.0.228

Pinging 172.16.0.228 with 32 bytes of data:

Reply from 172.16.0.228: bytes=32 time=1ms TTL=128  
 Reply from 172.16.0.228: bytes=32 time=0ms TTL=128  
 Reply from 172.16.0.228: bytes=32 time=0ms TTL=128  
 Reply from 172.16.0.228: bytes=32 time=0ms TTL=128

PC>ping 172.16.0.229

Pinging 172.16.0.229 with 32 bytes of data:

Reply from 172.16.0.229: bytes=32 time=1ms TTL=128  
 Reply from 172.16.0.229: bytes=32 time=0ms TTL=128  
 Reply from 172.16.0.229: bytes=32 time=0ms TTL=128  
 Reply from 172.16.0.229: bytes=32 time=0ms TTL=128

#### TASK: Inter-vlan routing

- Create subinterfaces on routers so that we can ensure that users of different vlan can ping with each other.
- Configure on switch-A f0/20 as trunk port for intervlan routing.
- Use the first ip address of the range for default gateway.
- on PC already gateway address is given

SW-A(config)#int f0/20

SW-A(config-if)#switchport mode trunk

SW-A(config-if)#end

SW-A#sh interfaces trunk

| Port   | Mode | Encapsulation | Status   | Native vlan |
|--------|------|---------------|----------|-------------|
| Fa0/20 | on   | 802.1q        | trunking | 1           |
| Fa0/21 | on   | 802.1q        | trunking | 1           |
| Fa0/24 | on   | 802.1q        | trunking | 1           |

| Port   | Vlans allowed on trunk |
|--------|------------------------|
| Fa0/20 | 1-1005                 |
| Fa0/21 | 1-1005                 |
| Fa0/24 | 1-1005                 |

| Port   | Vlans allowed and active in management domain |
|--------|-----------------------------------------------|
| Fa0/20 | 1,10,20,30,40                                 |

Fa0/21 1,10,20,30,40  
Fa0/24 1,10,20,30,40

Port Vlans in spanning tree forwarding state and not pruned

Fa0/20 1,10,20,30,40  
Fa0/21 1,10,20,30,40  
Fa0/24 1,10,20,30,40

R-1(config)#do sh ip int br

| Interface       | IP-Address   | OK? | Method | Status                | Protocol |
|-----------------|--------------|-----|--------|-----------------------|----------|
| FastEthernet0/0 | 172.16.0.1   | YES | manual | up                    | up       |
| FastEthernet0/1 | unassigned   | YES | unset  | administratively down | down     |
| Serial0/0       | 172.16.3.229 | YES | manual | up                    | up       |
| Serial0/1       | 172.16.3.225 | YES | manual | up                    | up       |

R-1(config)#int f0/0

R-1(config-if)#no ip address

R-1(config-if)#no shutdown

R-1(config-if)#exit

R-1(config)#interface f0/0.10

R-1(config-subif)#encapsulation dot1Q 10

R-1(config-subif)#ip address 172.16.0.1 255.255.255.128

R-1(config-subif)#exit

R-1(config)#int f0/0.20

R-1(config-subif)#encapsulation dot1Q 20

R-1(config-subif)#ip address 172.16.0.129 255.255.255.192

R-1(config-subif)#exit

R-1(config)#int f0/0.30

R-1(config-subif)#encapsulation dot1Q 30

R-1(config-subif)#ip address 172.16.0.193 255.255.255.224

R-1(config-subif)#exit

R-1(config)#int f0/0.40

R-1(config-subif)#encapsulation dot1Q 40

R-1(config-subif)#ip address 172.16.0.225 255.255.255.240

R-1(config)#end

R-1#sh ip int brief

| Interface          | IP-Address   | OK? | Method | Status                | Protocol |
|--------------------|--------------|-----|--------|-----------------------|----------|
| FastEthernet0/0    | unassigned   | YES | manual | up                    | up       |
| FastEthernet0/0.10 | 172.16.0.1   | YES | manual | up                    | up       |
| FastEthernet0/0.20 | 172.16.0.129 | YES | manual | up                    | up       |
| FastEthernet0/0.30 | 172.16.0.193 | YES | manual | up                    | up       |
| FastEthernet0/0.40 | 172.16.0.225 | YES | manual | up                    | up       |
| FastEthernet0/1    | unassigned   | YES | unset  | administratively down | down     |
| Serial0/0          | 172.16.3.229 | YES | manual | up                    | up       |
| Serial0/1          | 172.16.3.225 | YES | manual | up                    | up       |

R-1#ping 172.16.0.2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 172.16.0.2, timeout is 2 seconds:

.!!!!

Success rate is 80 percent (4/5), round-trip min/avg/max = 0/0/1 ms

R-1#ping 172.16.0.3

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 172.16.0.3, timeout is 2 seconds:

.!!!!

Success rate is 80 percent (4/5), round-trip min/avg/max = 0/0/0 ms

R-1#ping 172.16.0.4

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 172.16.0.4, timeout is 2 seconds:

.!!!!

Success rate is 80 percent (4/5), round-trip min/avg/max = 0/0/1 ms

R-1#ping 172.16.0.5

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 172.16.0.5, timeout is 2 seconds:

.!!!!

Success rate is 80 percent (4/5), round-trip min/avg/max = 0/0/1 ms

R-1#ping 172.16.0.130

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 172.16.0.130, timeout is 2 seconds:

.!!!!

Success rate is 80 percent (4/5), round-trip min/avg/max = 0/0/0 ms

R-1#ping 172.16.0.131

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 172.16.0.131, timeout is 2 seconds:

.!!!!

Success rate is 80 percent (4/5), round-trip min/avg/max = 0/2/9 ms

R-1#ping 172.16.0.132

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 172.16.0.132, timeout is 2 seconds:

.!!!!

Success rate is 80 percent (4/5), round-trip min/avg/max = 0/0/1 ms

R-1#ping 172.16.0.133

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 172.16.0.133, timeout is 2 seconds:

.!!!!

Success rate is 80 percent (4/5), round-trip min/avg/max = 0/0/2 ms

PC>ipconfig

FastEthernet0 Connection:(default port)

Link-local IPv6 Address.....: FE80::203:E4FF:FE9B:E9AE



IP Address.....: 172.16.0.2  
Subnet Mask.....: 255.255.255.128  
Default Gateway.....: 172.16.0.1

PC>ping 172.16.0.130

Pinging 172.16.0.130 with 32 bytes of data:

Reply from 172.16.0.130: bytes=32 time=1ms TTL=127  
Reply from 172.16.0.130: bytes=32 time=0ms TTL=127  
Reply from 172.16.0.130: bytes=32 time=0ms TTL=127  
Reply from 172.16.0.130: bytes=32 time=0ms TTL=127

PC>tracert 172.16.0.130

Tracing route to 172.16.0.130 over a maximum of 30 hops:

|   |      |      |      |              |
|---|------|------|------|--------------|
| 1 | 0 ms | 0 ms | 0 ms | 172.16.0.1   |
| 2 | 0 ms | 0 ms | 0 ms | 172.16.0.130 |

Trace complete.

PC>ping 172.16.0.194

Pinging 172.16.0.194 with 32 bytes of data:

Request timed out.  
Reply from 172.16.0.194: bytes=32 time=0ms TTL=127  
Reply from 172.16.0.194: bytes=32 time=0ms TTL=127  
Reply from 172.16.0.194: bytes=32 time=1ms TTL=127

PC>tracert 172.16.0.194

Tracing route to 172.16.0.194 over a maximum of 30 hops:

|   |      |      |      |              |
|---|------|------|------|--------------|
| 1 | 1 ms | 0 ms | 0 ms | 172.16.0.1   |
| 2 | 0 ms | 0 ms | 0 ms | 172.16.0.194 |

Trace complete.

PC>ping 172.16.0.226

Pinging 172.16.0.226 with 32 bytes of data:

Request timed out.  
Reply from 172.16.0.226: bytes=32 time=0ms TTL=127  
Reply from 172.16.0.226: bytes=32 time=0ms TTL=127  
Reply from 172.16.0.226: bytes=32 time=0ms TTL=127

PC>tracert 172.16.0.226

Tracing route to 172.16.0.226 over a maximum of 30 hops:

|   |      |      |      |              |
|---|------|------|------|--------------|
| 1 | 1 ms | 0 ms | 0 ms | 172.16.0.1   |
| 2 | 2 ms | 0 ms | 0 ms | 172.16.0.226 |

Trace complete.

## TASK: SPANNING-TREE PROTOCOL

- verify who is the root bridge , what are Rootports and Blocking ports:

SW-A#sh spanning-tree vlan 10

VLAN0010

Spanning tree enabled protocol ieee

Root ID Priority 32778

Address 0001.961D.27A8

Cost 19

Port 21(FastEthernet0/21)

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32778 (priority 32768 sys-id-ext 10)

Address 0003.E4C6.9979

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Aging Time 20

| Interface | Role | Sts | Cost | Prio.  | Nbr | Type |
|-----------|------|-----|------|--------|-----|------|
| -----     |      |     |      |        |     |      |
| Fa0/1     | Desg | FWD | 19   | 128.1  | P2p |      |
| Fa0/2     | Desg | FWD | 19   | 128.2  | P2p |      |
| Fa0/20    | Desg | FWD | 19   | 128.20 | P2p |      |
| Fa0/21    | Root | FWD | 19   | 128.21 | P2p |      |
| Fa0/24    | Desg | FWD | 19   | 128.24 | P2p |      |

SW-A#sh spanning-tree vlan 20

VLAN0020

Spanning tree enabled protocol ieee

Root ID Priority 32788

Address 0001.961D.27A8

Cost 19

Port 21(FastEthernet0/21)

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32788 (priority 32768 sys-id-ext 20)

Address 0003.E4C6.9979

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Aging Time 20

| Interface | Role | Sts | Cost | Prio.  | Nbr | Type |
|-----------|------|-----|------|--------|-----|------|
| -----     |      |     |      |        |     |      |
| Fa0/3     | Desg | FWD | 19   | 128.3  | P2p |      |
| Fa0/4     | Desg | FWD | 19   | 128.4  | P2p |      |
| Fa0/20    | Desg | FWD | 19   | 128.20 | P2p |      |
| Fa0/21    | Root | FWD | 19   | 128.21 | P2p |      |
| Fa0/24    | Desg | FWD | 19   | 128.24 | P2p |      |

SW-A#sh spanning-tree vlan 30

VLAN0030

Spanning tree enabled protocol ieee

Root ID Priority 32798

Address 0001.961D.27A8  
Cost 19  
Port 21(FastEthernet0/21)  
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32798 (priority 32768 sys-id-ext 30)  
Address 0003.E4C6.9979  
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec  
Aging Time 20

| Interface | Role | Sts | Cost | Prio.  | Nbr | Type |
|-----------|------|-----|------|--------|-----|------|
| Fa0/20    | Desg | FWD | 19   | 128.20 | P2p |      |
| Fa0/21    | Root | FWD | 19   | 128.21 | P2p |      |
| Fa0/24    | Desg | FWD | 19   | 128.24 | P2p |      |

SW-A#sh spanning-tree vlan 40

VLAN0040

Spanning tree enabled protocol ieee  
Root ID Priority 32808  
Address 0001.961D.27A8  
Cost 19  
Port 21(FastEthernet0/21)  
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32808 (priority 32768 sys-id-ext 40)  
Address 0003.E4C6.9979  
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec  
Aging Time 20

| Interface | Role | Sts | Cost | Prio.  | Nbr | Type |
|-----------|------|-----|------|--------|-----|------|
| Fa0/20    | Desg | FWD | 19   | 128.20 | P2p |      |
| Fa0/21    | Root | FWD | 19   | 128.21 | P2p |      |
| Fa0/24    | Desg | FWD | 19   | 128.24 | P2p |      |

SW-B#sh spanning-tree vlan 10

VLAN0010

Spanning tree enabled protocol ieee  
Root ID Priority 32778  
Address 0001.961D.27A8  
This bridge is the root  
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32778 (priority 32768 sys-id-ext 10)  
Address 0001.961D.27A8  
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec  
Aging Time 20

| Interface | Role | Sts | Cost | Prio. | Nbr | Type |
|-----------|------|-----|------|-------|-----|------|
| Fa0/1     | Desg | FWD | 19   | 128.1 | P2p |      |



|        |             |        |     |
|--------|-------------|--------|-----|
| Fa0/2  | Desg FWD 19 | 128.2  | P2p |
| Fa0/21 | Desg FWD 19 | 128.21 | P2p |
| Fa0/22 | Desg FWD 19 | 128.22 | P2p |

# SW-C#sh spanning-tree vlan 30

VLAN0030

Spanning tree enabled protocol ieee

Root ID Priority 32798

Address 0001.961D.27A8

Cost 38

Port 24(FastEthernet0/24)

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32798 (priority 32768 sys-id-ext 30)

Address 0060.2F5C.88BD

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Aging Time 20

| Interface | Role | Sts | Cost | Prio. | Nbr | Type |
|-----------|------|-----|------|-------|-----|------|
|-----------|------|-----|------|-------|-----|------|

|        |      |     |    |        |     |  |
|--------|------|-----|----|--------|-----|--|
| Fa0/23 | Altn | BLK | 19 | 128.23 | P2p |  |
| Fa0/24 | Root | FWD | 19 | 128.24 | P2p |  |
| Fa0/1  | Desg | FWD | 19 | 128.1  | P2p |  |
| Fa0/2  | Desg | FWD | 19 | 128.2  | P2p |  |

# SW-D#sh spanning-tree vlan 10

VLAN0010

Spanning tree enabled protocol ieee

Root ID Priority 32778

Address 0001.961D.27A8

Cost 19

Port 22(FastEthernet0/22)

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32778 (priority 32768 sys-id-ext 10)

Address 0090.2B3D.96E2

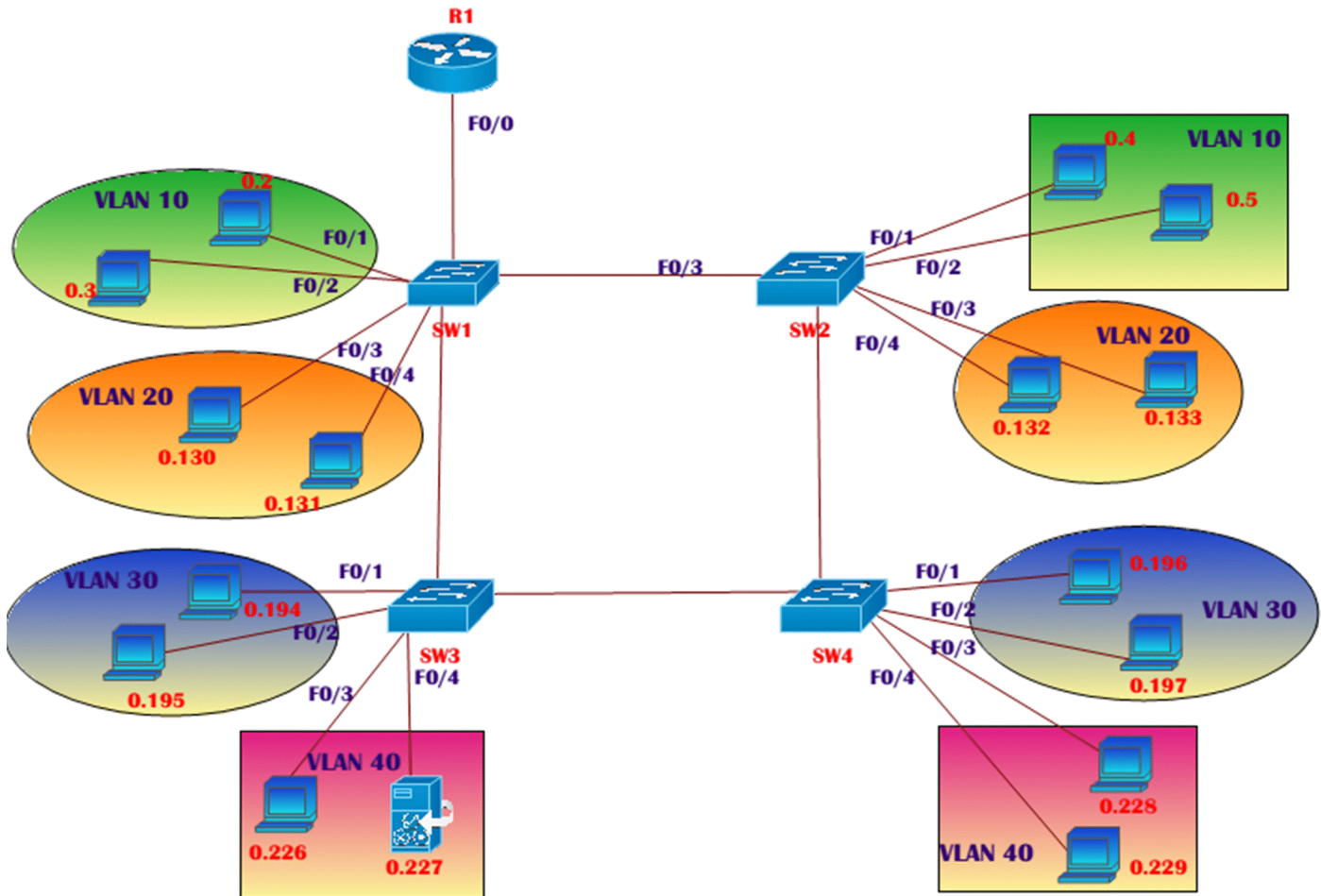
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Aging Time 20

| Interface | Role | Sts | Cost | Prio. | Nbr | Type |
|-----------|------|-----|------|-------|-----|------|
|-----------|------|-----|------|-------|-----|------|

|        |      |     |    |        |     |  |
|--------|------|-----|----|--------|-----|--|
| Fa0/22 | Root | FWD | 19 | 128.22 | P2p |  |
| Fa0/23 | Desg | FWD | 19 | 128.23 | P2p |  |

## MOCK LAB: ACCESS CONTROL LIST



### TASK:

- Configure ACL to stop Interval routing for selecting vlan and hosts;
- Deny vlan 10 users (172.16.0.0/25) accessing FTP server on vlan 40 (172.16.0.226/28)
- Deny vlan 20 users (172.16.0.128/26) accessing HTTP server on vlan 40 (172.16.0.227/28)
- Deny vlan 30 users (172.16.0.192/27) from sending ICMP to host (172.16.0.228/28) on vlan 40
- Ensure that all the remaining traffic must be allowed.
- Use Named ACL.

```
R-1(config)#ip access-list extended CCNA
```

```
R-1(config-ext-nacl)#deny tcp 172.16.0.0 0.0.0.127 host 172.16.0.226 eq ftp
```

```
R-1(config-ext-nacl)#deny tcp 172.16.0.128 0.0.0.63 host 172.16.0.227 eq www
```

```
R-1(config-ext-nacl)#deny icmp 172.16.0.192 0.0.0.31 host 172.16.0.228 echo
```

```
R-1(config-ext-nacl)#deny icmp 172.16.0.192 0.0.0.31 host 172.16.0.228 echo-reply
```

```
R-1(config-ext-nacl)#permit ip any any
```

```
R-1(config-ext-nacl)#exit
```

```
R-1#sh ip access-lists
```

```
Extended IP access list CCNA
```

```
10 deny tcp 172.16.0.0 0.0.0.127 host 172.16.0.226 eq ftp
```

```
20 deny tcp 172.16.0.128 0.0.0.63 host 172.16.0.227 eq www
```

```
30 deny icmp 172.16.0.192 0.0.0.31 host 172.16.0.228 echo
```

```
40 deny icmp 172.16.0.192 0.0.0.31 host 172.16.0.228 echo-reply
50 permit ip any any
```

```
R-1(config)#interface f0/0.40
R-1(config-subif)#ip access-group CCNA out
R-1(config-subif)#exit
```

Generate some traffic between hosts and verify Show ip access-list.

```
PC>ipconfig
FastEthernet0 Connection:(default port)
Link-local IPv6 Address.....: FE80::201:C9FF:FE8A:B64D
IP Address.....: 172.16.0.194
Subnet Mask.....: 255.255.255.224
Default Gateway.....: 172.16.0.193
```

```
PC>ping 172.16.0.228
Pinging 172.16.0.228 with 32 bytes of data:
```

```
Reply from 172.16.0.193: Destination host unreachable.
Reply from 172.16.0.193: Destination host unreachable.
Reply from 172.16.0.193: Destination host unreachable.
Reply from 172.16.0.193: Destination host unreachable.
```

```
PC>ping 172.16.0.226
Pinging 172.16.0.226 with 32 bytes of data:
```

```
Request timed out.
Reply from 172.16.0.226: bytes=32 time=6ms TTL=127
Reply from 172.16.0.226: bytes=32 time=1ms TTL=127
Reply from 172.16.0.226: bytes=32 time=0ms TTL=127
```

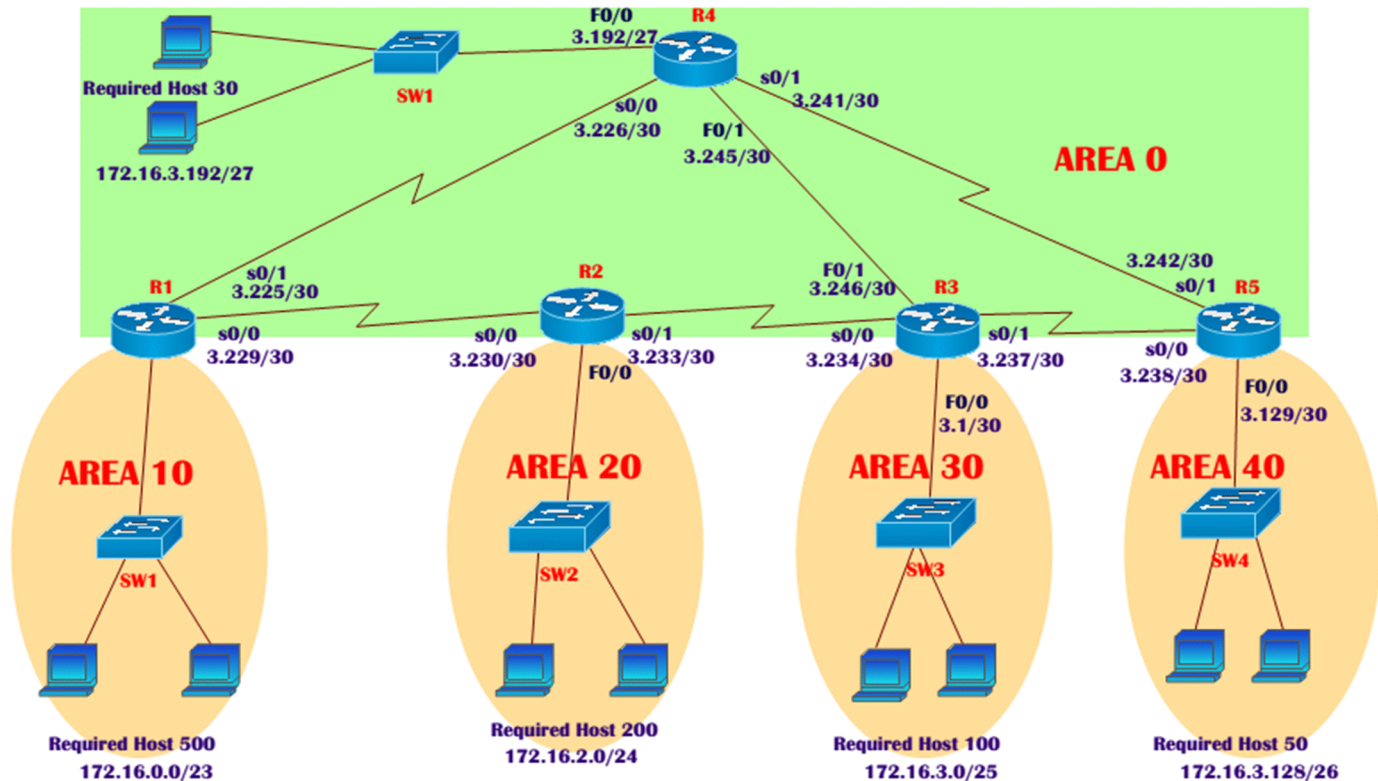
```
R-1#sh access-lists
```

```
Extended IP access list CCNA
10 deny tcp 172.16.0.0 0.0.0.127 host 172.16.0.226 eq ftp
20 deny tcp 172.16.0.128 0.0.0.63 host 172.16.0.227 eq www (12 match(es))
30 deny icmp 172.16.0.192 0.0.0.31 host 172.16.0.228 echo (4 match(es))
40 deny icmp 172.16.0.192 0.0.0.31 host 172.16.0.228 echo-reply
50 permit ip any any (10 match(es))
```



## TASK: ACL

- Deny the traffic from R4 LAN users from accessing R5 HTTP server
- Deny the traffic from R3 LAN users from accessing R5 FTP server
- Ensure that all the remaining traffic must be allowed.
- Use Named ACL.

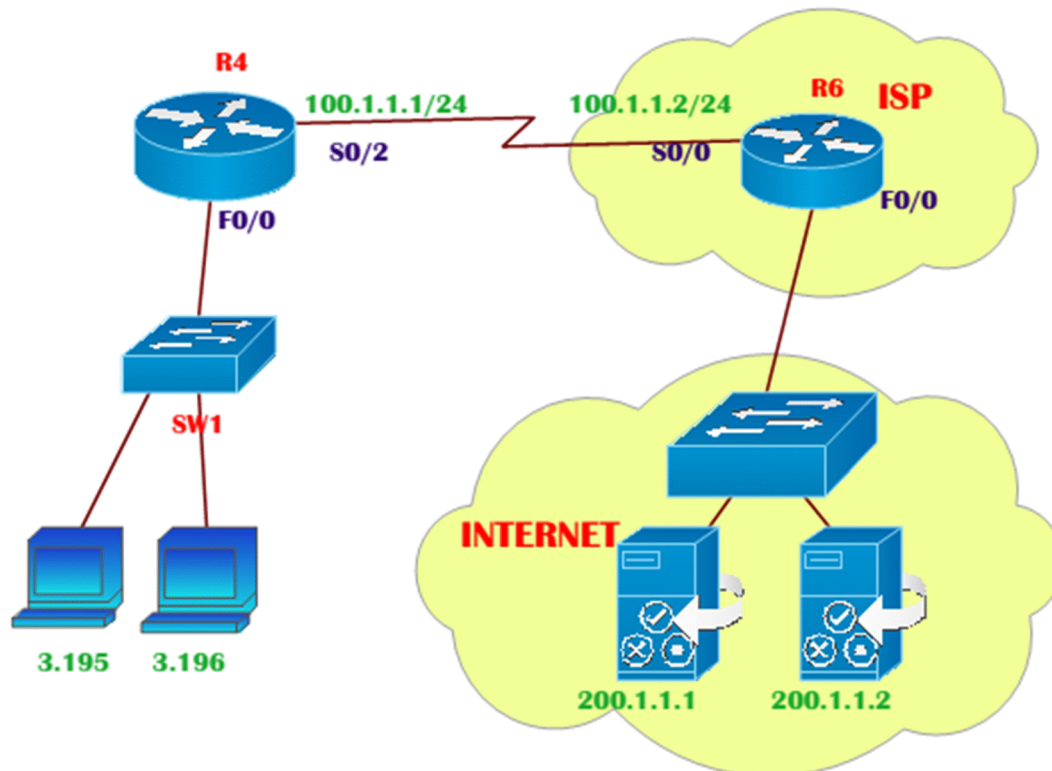


```
R-5(config)#ip access-list extended CCNP
R-5(config-ext-nacl)# deny tcp 172.16.3.192 0.0.0.31 host 172.16.3.130 eq www
R-5(config-ext-nacl)# deny tcp 172.16.3.0 0.0.0.127 host 172.16.3.131 eq ftp
R-5(config-ext-nacl)# permit ip any any
R-5(config-ext-nacl)# exit
```

```
R-5(config)# int f0/0
R-5(config-if)# ip access-group CCNP out
R-5(config-if)#end
```

```
R-5#sh ip access-lists
Extended IP access list CCNP
 10 deny tcp 172.16.3.192 0.0.0.31 host 172.16.3.130 eq www
 20 deny tcp 172.16.3.0 0.0.0.127 host 172.16.3.131 eq ftp
 30 permit ip any any
```

## NETWORK ADDRESS TRANSLATION:



### TASK:

- Connect R6 and assign IP addressing as per the diagram.
- Use Default and Static and per the lab requirement to provide reachability between R4 and R6(ISP).
- Configure NAT and translate all the private IP addressing on R4 LAN should get translated to public IP (50.1.1.1/32)

```
R-4(config)#interface s0/2
R-4(config-if)#ip address 100.1.1.1 255.255.255.0
R-4(config-if)#no shutdown
R-4(config-if)#clock rate 64000
R-4(config-if)#exit
```

```
R-4#sh ip int brief
```

| Interface       | IP-Address   | OK? | Method | Status | Protocol |
|-----------------|--------------|-----|--------|--------|----------|
| FastEthernet0/0 | 172.16.3.193 | YES | manual | up     | up       |
| FastEthernet0/1 | 172.16.3.245 | YES | manual | up     | up       |
| Serial0/0       | 172.16.3.226 | YES | manual | up     | up       |
| Serial0/1       | 172.16.3.241 | YES | manual | up     | up       |
| Serial0/2       | 100.1.1.1    | YES | manual | up     | up       |
| Serial0/3       | unassigned   | YES | unset  | down   | down     |

```
Router(config)#hostname ISP
```

```
ISP(config)#interface f0/0
ISP(config-if)#ip address 200.1.1.100 255.255.255.0
ISP(config-if)#no shutdown
```

```
ISP(config-if)#exit
```

```
ISP(config)#interface s0/0
```

```
ISP(config-if)#ip address 100.1.1.2 255.255.255.0
```

```
ISP(config-if)#no shutdown
```

```
ISP(config-if)#clock rate 64000
```

```
ISP(config-if)#end
```

```
ISP#sh ip int brief
```

| Interface       | IP-Address  | OK? | Method | Status                | Protocol |
|-----------------|-------------|-----|--------|-----------------------|----------|
| FastEthernet0/0 | 200.1.1.100 | YES | manual | up                    | up       |
| FastEthernet0/1 | unassigned  | YES | unset  | administratively down | down     |
| Serial0/0       | 100.1.1.2   | YES | manual | up                    | up       |
| Serial0/1       | unassigned  | YES | unset  | administratively down | down     |

```
ISP(config)#ip route 50.1.1.0 255.255.255.0 100.1.1.1
```

```
ISP(config)#exit
```

```
ISP#sh ip route
```

Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP

D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area

N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2

E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP

i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area

\* - candidate default, U - per-user static route, o - ODR

P - periodic downloaded static route

Gateway of last resort is not set

50.0.0.0/24 is subnetted, 1 subnets

**S 50.1.1.0 [1/0] via 100.1.1.1**

100.0.0.0/24 is subnetted, 1 subnets

C 100.1.1.0 is directly connected, Serial0/0

C 200.1.1.0/24 is directly connected, FastEthernet0/0

```
R-4(config)#ip route 0.0.0.0 0.0.0.0 100.1.1.2
```

```
R-4(config)#exit
```

```
R-4#sh ip route
```

Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP

D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area

N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2

E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP

i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area

\* - candidate default, U - per-user static route, o - ODR

P - periodic downloaded static route

Gateway of last resort is 100.1.1.2 to network 0.0.0.0

100.0.0.0/24 is subnetted, 1 subnets

C 100.1.1.0 is directly connected, Serial0/2

172.16.0.0/16 is variably subnetted, 15 subnets, 7 masks

O IA 172.16.0.0/25 [110/65] via 172.16.3.225, 00:26:15, Serial0/0



```

O IA 172.16.0.128/26 [110/65] via 172.16.3.225, 00:26:15, Serial0/0
O IA 172.16.0.192/27 [110/65] via 172.16.3.225, 00:26:15, Serial0/0
O IA 172.16.0.224/28 [110/65] via 172.16.3.225, 00:26:15, Serial0/0
O IA 172.16.2.0/24 [110/66] via 172.16.3.246, 00:25:45, FastEthernet0/1
O IA 172.16.3.0/25 [110/2] via 172.16.3.246, 00:25:45, FastEthernet0/1
O IA 172.16.3.128/26 [110/65] via 172.16.3.242, 00:26:15, Serial0/1
C 172.16.3.192/27 is directly connected, FastEthernet0/0
C 172.16.3.224/30 is directly connected, Serial0/0
C 172.16.3.225/32 is directly connected, Serial0/0
O 172.16.3.228/30 [110/128] via 172.16.3.225, 00:26:15, Serial0/0
O 172.16.3.232/30 [110/65] via 172.16.3.246, 00:25:45, FastEthernet0/1
O 172.16.3.236/30 [110/65] via 172.16.3.246, 00:25:45, FastEthernet0/1
C 172.16.3.240/30 is directly connected, Serial0/1
C 172.16.3.244/30 is directly connected, FastEthernet0/1
S* 0.0.0.0/0 [1/0] via 100.1.1.2

```

```

R-4(config)# access-list 25 permit 172.16.3.192 0.0.0.31
R-4(config)# ip nat pool CCNA 50.1.1.1 50.1.1.1 netmask 255.255.255.255
R-4(config)# ip nat inside source list 25 pool CCNA overload

```

```

R-4(config)# int s0/2
R-4(config-if)# ip nat outside
R-4(config-if)# exit

```

```

R-4(config)# int f0/0
R-4(config-if)# ip nat inside
R-4(config-if)#end

```

Generate traffic from R4 LAN and verify:

```

PC>ipconfig
FastEthernet0 Connection:(default port)
Link-local IPv6 Address.....: FE80::260:70FF:FE18:181C
IP Address.....: 172.16.3.195
Subnet Mask.....: 255.255.255.224
Default Gateway.....: 172.16.3.193

```

```

PC>ping 200.1.1.1
Pinging 200.1.1.1 with 32 bytes of data:
Reply from 200.1.1.1: bytes=32 time=1ms TTL=126
Reply from 200.1.1.1: bytes=32 time=1ms TTL=126
Reply from 200.1.1.1: bytes=32 time=1ms TTL=126
Reply from 200.1.1.1: bytes=32 time=1ms TTL=126

```

```

R-4#sh ip nat translations
Pro Inside global Inside local Outside local Outside global
icmp 50.1.1.1:1 172.16.3.195:1 200.1.1.1:1 200.1.1.1:1
icmp 50.1.1.1:2 172.16.3.195:2 200.1.1.1:2 200.1.1.1:2
icmp 50.1.1.1:3 172.16.3.195:3 200.1.1.1:3 200.1.1.1:3
icmp 50.1.1.1:4 172.16.3.195:4 200.1.1.1:4 200.1.1.1:4
icmp 50.1.1.1:5 172.16.3.195:5 200.1.1.1:5 200.1.1.1:5

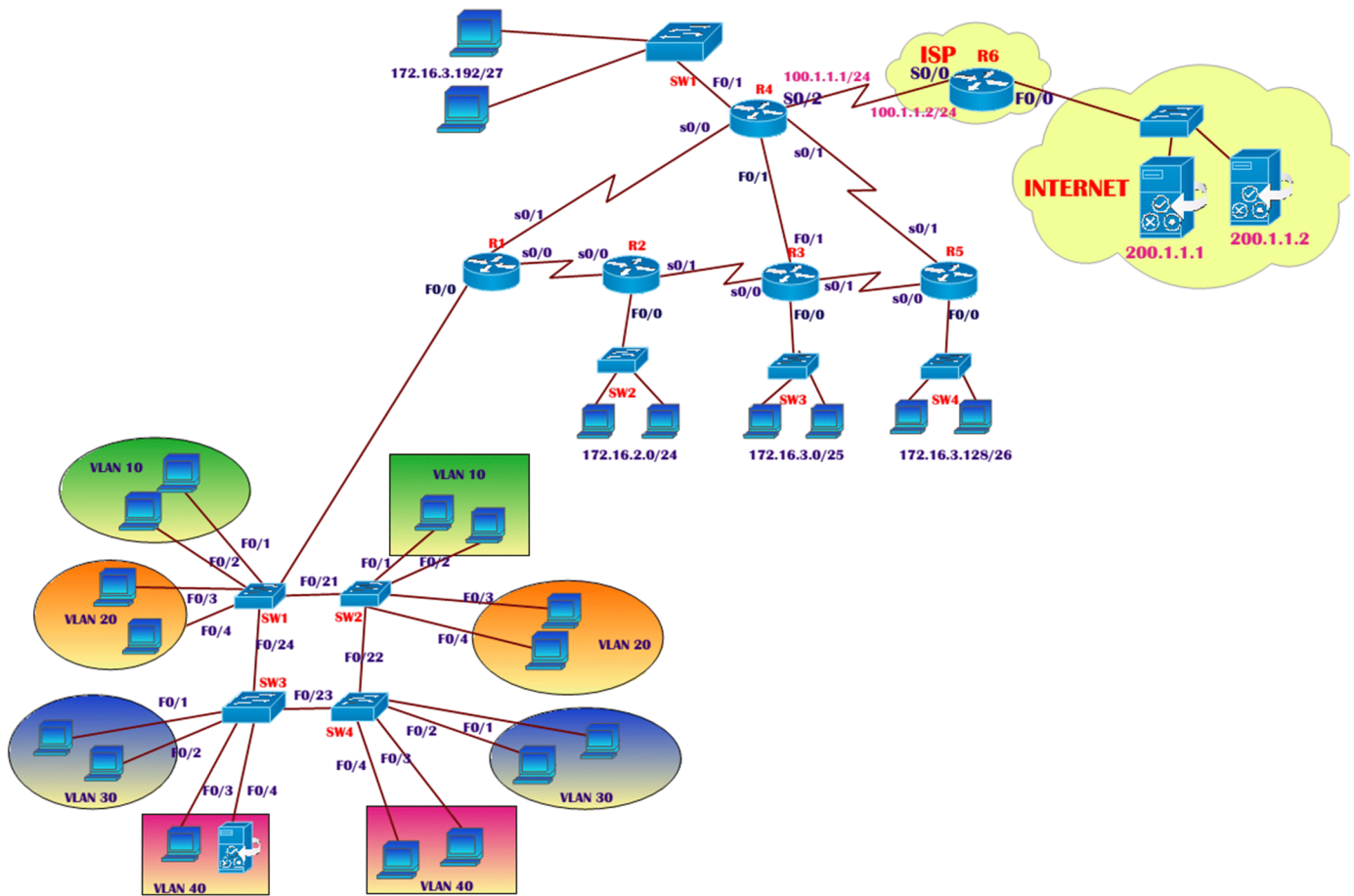
```

|                   |                   |              |              |
|-------------------|-------------------|--------------|--------------|
| icmp 50.1.1.1:6   | 172.16.3.195:6    | 200.1.1.1:6  | 200.1.1.1:6  |
| icmp 50.1.1.1:7   | 172.16.3.195:7    | 200.1.1.1:7  | 200.1.1.1:7  |
| icmp 50.1.1.1:8   | 172.16.3.195:8    | 200.1.1.1:8  | 200.1.1.1:8  |
| tcp 50.1.1.1:1025 | 172.16.3.194:1025 | 200.1.1.1:80 | 200.1.1.1:80 |
| tcp 50.1.1.1:1026 | 172.16.3.194:1026 | 200.1.1.1:80 | 200.1.1.1:80 |



### TASK:

- Configure R4 to advertise the default route inside the OSPF
- Ensure that all the others routers should see default route.



```
R-4(config)#router ospf 1
R-4(config-router)#redistribute static subnets
R-4(config-router)#exit
```

OR

```
R-4(config)# router ospf 1
R-4(config-router)# default-information originate
R-4(config-router)# end
```

```
R-5#sh ip route ospf
172.16.0.0/16 is variably subnetted, 14 subnets, 6 masks
O IA 172.16.0.0 [110/129] via 172.16.3.241, 00:35:34, Serial0/1
O IA 172.16.0.128 [110/129] via 172.16.3.241, 00:35:34, Serial0/1
O IA 172.16.0.192 [110/129] via 172.16.3.241, 00:35:34, Serial0/1
O IA 172.16.0.224 [110/129] via 172.16.3.241, 00:35:34, Serial0/1
O IA 172.16.2.0 [110/129] via 172.16.3.237, 01:15:00, Serial0/0
O IA 172.16.3.0 [110/65] via 172.16.3.237, 01:14:15, Serial0/0
O 172.16.3.192 [110/65] via 172.16.3.241, 00:35:34, Serial0/1
O 172.16.3.224 [110/128] via 172.16.3.241, 00:35:34, Serial0/1
```



- 172.16.3.228 [110/192] via 172.16.3.237, 00:35:34, Serial0/0  
[110/192] via 172.16.3.241, 00:35:34, Serial0/1
- 172.16.3.232 [110/128] via 172.16.3.237, 01:15:00, Serial0/0
- 172.16.3.244 [110/65] via 172.16.3.237, 00:35:04, Serial0/0  
[110/65] via 172.16.3.241, 00:35:04, Serial0/1
- \*E2 0.0.0.0/0 [110/1] via 172.16.3.241, 00:00:38, Serial0/1

R-1#sh ip route

Gateway of last resort is 172.16.3.226 to network 0.0.0.0  
172.16.0.0/16 is variably subnetted, 16 subnets, 7 masks

- C 172.16.0.0/25 is directly connected, FastEthernet0/0.10
- C 172.16.0.128/26 is directly connected, FastEthernet0/0.20
- C 172.16.0.192/27 is directly connected, FastEthernet0/0.30
- C 172.16.0.224/28 is directly connected, FastEthernet0/0.40
- IA 172.16.2.0/24 [110/65] via 172.16.3.230, 01:15:25, Serial0/0
- IA 172.16.3.0/25 [110/66] via 172.16.3.226, 00:35:37, Serial0/1
- IA 172.16.3.128/26 [110/129] via 172.16.3.226, 00:36:07, Serial0/1
- 172.16.3.192/27 [110/65] via 172.16.3.226, 00:36:07, Serial0/1
- C 172.16.3.224/30 is directly connected, Serial0/1
- C 172.16.3.226/32 is directly connected, Serial0/1
- C 172.16.3.228/30 is directly connected, Serial0/0
- C 172.16.3.230/32 is directly connected, Serial0/0
- 172.16.3.232/30 [110/128] via 172.16.3.230, 01:15:25, Serial0/0
- 172.16.3.236/30 [110/129] via 172.16.3.226, 00:35:37, Serial0/1
- 172.16.3.240/30 [110/128] via 172.16.3.226, 00:36:07, Serial0/1
- 172.16.3.244/30 [110/65] via 172.16.3.226, 00:35:37, Serial0/1
- \*E2 0.0.0.0/0 [110/1] via 172.16.3.226, 00:01:11, Serial0/1

R-1#

R-2#sh ip route ospf

172.16.0.0/16 is variably subnetted, 15 subnets, 7 masks

- IA 172.16.0.0 [110/65] via 172.16.3.229, 01:15:46, Serial0/0
- IA 172.16.0.128 [110/65] via 172.16.3.229, 01:15:46, Serial0/0
- IA 172.16.0.192 [110/65] via 172.16.3.229, 01:15:46, Serial0/0
- IA 172.16.0.224 [110/65] via 172.16.3.229, 01:15:46, Serial0/0
- IA 172.16.3.0 [110/65] via 172.16.3.234, 01:15:12, Serial0/1
- IA 172.16.3.128 [110/129] via 172.16.3.234, 01:15:46, Serial0/1
- 172.16.3.192 [110/66] via 172.16.3.234, 00:36:01, Serial0/1
- 172.16.3.224 [110/128] via 172.16.3.229, 00:36:41, Serial0/0
- 172.16.3.236 [110/128] via 172.16.3.234, 01:15:57, Serial0/1
- 172.16.3.240 [110/129] via 172.16.3.234, 00:36:01, Serial0/1
- 172.16.3.244 [110/65] via 172.16.3.234, 00:36:41, Serial0/1
- \*E2 0.0.0.0/0 [110/1] via 172.16.3.234, 00:01:35, Serial0/1

R-3#sh ip route ospf

172.16.0.0/16 is variably subnetted, 14 subnets, 6 masks

- IA 172.16.0.0 [110/66] via 172.16.3.245, 00:36:16, FastEthernet0/1
- IA 172.16.0.128 [110/66] via 172.16.3.245, 00:36:16, FastEthernet0/1
- IA 172.16.0.192 [110/66] via 172.16.3.245, 00:36:16, FastEthernet0/1
- IA 172.16.0.224 [110/66] via 172.16.3.245, 00:36:16, FastEthernet0/1

- IA 172.16.2.0 [110/65] via 172.16.3.233, 01:16:11, Serial0/0
- IA 172.16.3.128 [110/65] via 172.16.3.238, 01:16:01, Serial0/1
- 172.16.3.192 [110/2] via 172.16.3.245, 00:36:16, FastEthernet0/1
- 172.16.3.224 [110/65] via 172.16.3.245, 00:36:16, FastEthernet0/1
- 172.16.3.228 [110/128] via 172.16.3.233, 01:16:11, Serial0/0
- 172.16.3.240 [110/65] via 172.16.3.245, 00:36:16, FastEthernet0/1
- \*E2 0.0.0.0/0 [110/1] via 172.16.3.245, 00:01:50, FastEthernet0/1

#### TASK:

- Ensure that all the branch office users should be able to access internet servers (200.1.1.1, 200.1.1.2)

R-4#sh access-lists

```
Standard IP access list 25
 permit 172.16.3.192 0.0.0.31 (20 match(es))
```

Here we just need to modify the ACL to add the branches on the other routers

```
R-4(config)#access-list 25 permit 172.16.0.0 0.0.1.255
R-4(config)#access-list 25 permit 172.16.2.0 0.0.0.255
R-4(config)#access-list 25 permit 172.16.3.0 0.0.0.127
R-4(config)#access-list 25 permit 172.16.3.128 0.0.0.63
```

R-4#sh access-lists

```
Standard IP access list 25
 permit 172.16.3.192 0.0.0.31 (20 match(es))
 permit 172.16.0.0 0.0.1.255
 permit 172.16.2.0 0.0.0.255
 permit 172.16.3.0 0.0.0.127
 permit 172.16.3.128 0.0.0.63
```

R-4(config)#int s0/0

R-4(config-if)#ip nat inside

R-4(config-if)#exit

R-4(config)#int s0/1

R-4(config-if)#ip nat inside

R-4(config-if)#int f0/1

R-4(config-if)#ip nat inside

R-4(config-if)#end

PC>ipconfig

```
FastEthernet0 Connection:(default port)
Link-local IPv6 Address.....: FE80::203:E4FF:FE9B:E9AE
IP Address.....: 172.16.0.2
Subnet Mask.....: 255.255.255.128
Default Gateway.....: 172.16.0.1
```

PC>ping 200.1.1.1

Pinging 200.1.1.1 with 32 bytes of data:

Reply from 200.1.1.1: bytes=32 time=2ms TTL=125

Reply from 200.1.1.1: bytes=32 time=3ms TTL=125  
Reply from 200.1.1.1: bytes=32 time=2ms TTL=125  
Reply from 200.1.1.1: bytes=32 time=2ms TTL=125

PC>ipconfig

FastEthernet0 Connection:(default port)  
Link-local IPv6 Address.....: FE80::20A:41FF:FE6A:D14A  
IP Address.....: 172.16.0.130  
Subnet Mask.....: 255.255.255.192  
Default Gateway.....: 172.16.0.129

PC>ping 200.1.1.1

Pinging 200.1.1.1 with 32 bytes of data:

Reply from 200.1.1.1: bytes=32 time=4ms TTL=125  
Reply from 200.1.1.1: bytes=32 time=10ms TTL=125  
Reply from 200.1.1.1: bytes=32 time=2ms TTL=125  
Reply from 200.1.1.1: bytes=32 time=3ms TTL=125

PC>ipconfig

FastEthernet0 Connection:(default port)  
Link-local IPv6 Address.....: FE80::201:C9FF:FE8A:B64D  
IP Address.....: 172.16.0.194  
Subnet Mask.....: 255.255.255.224  
Default Gateway.....: 172.16.0.193

PC>ping 200.1.1.2

Pinging 200.1.1.2 with 32 bytes of data:

Request timed out.  
Reply from 200.1.1.2: bytes=32 time=2ms TTL=125  
Reply from 200.1.1.2: bytes=32 time=4ms TTL=125  
Reply from 200.1.1.2: bytes=32 time=2ms TTL=125

PC>ipconfig

FastEthernet0 Connection:(default port)  
Link-local IPv6 Address.....: FE80::203:E4FF:FE56:D8BB  
IP Address.....: 172.16.0.226  
Subnet Mask.....: 255.255.255.240  
Default Gateway.....: 172.16.0.225

PC>ping 200.1.1.1

Pinging 200.1.1.1 with 32 bytes of data:

Reply from 200.1.1.1: bytes=32 time=3ms TTL=125  
Reply from 200.1.1.1: bytes=32 time=3ms TTL=125  
Reply from 200.1.1.1: bytes=32 time=2ms TTL=125  
Reply from 200.1.1.1: bytes=32 time=3ms TTL=125

PC>ipconfig

FastEthernet0 Connection:(default port)



Link-local IPv6 Address.....: FE80::20A:41FF:FE67:1977  
IP Address.....: 172.16.2.2  
Subnet Mask.....: 255.255.255.0  
Default Gateway.....: 172.16.2.1

PC>ping 200.1.1.1

Pinging 200.1.1.1 with 32 bytes of data:

Reply from 200.1.1.1: bytes=32 time=2ms TTL=124  
Reply from 200.1.1.1: bytes=32 time=11ms TTL=124  
Reply from 200.1.1.1: bytes=32 time=2ms TTL=124  
Reply from 200.1.1.1: bytes=32 time=2ms TTL=124

PC>ipconfig

FastEthernet0 Connection:(default port)  
Link-local IPv6 Address.....: FE80::230:F2FF:FEAC:BB83  
IP Address.....: 172.16.3.2  
Subnet Mask.....: 255.255.255.128  
Default Gateway.....: 172.16.3.1

PC>ping 200.1.1.1

Pinging 200.1.1.1 with 32 bytes of data:

Reply from 200.1.1.1: bytes=32 time=11ms TTL=125  
Reply from 200.1.1.1: bytes=32 time=1ms TTL=125  
Reply from 200.1.1.1: bytes=32 time=1ms TTL=125  
Reply from 200.1.1.1: bytes=32 time=1ms TTL=125

PC>ipconfig

FastEthernet0 Connection:(default port)  
Link-local IPv6 Address.....: FE80::201:96FF:FE77:DA66  
IP Address.....: 172.16.3.130  
Subnet Mask.....: 255.255.255.192  
Default Gateway.....: 172.16.3.129

PC>ping 200.1.1.2

Pinging 200.1.1.2 with 32 bytes of data:

Reply from 200.1.1.2: bytes=32 time=12ms TTL=125  
Reply from 200.1.1.2: bytes=32 time=2ms TTL=125  
Reply from 200.1.1.2: bytes=32 time=3ms TTL=125  
Reply from 200.1.1.2: bytes=32 time=10ms TTL=125

